Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

February 16th, 2022

(data current to February 12th – Feb 15th)

Biocomplexity Institute Technical report: TR 2022-012

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biocomplexity.virginia.edu

About Us

- Biocomplexity Institute at the University of Virginia
  - Using big data and simulations to understand massively interactive systems and solve societal problems
- Over 20 years of crafting and analyzing infectious disease models
  - Pandemic response for Influenza, Ebola, Zika, and others

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Overview

- **Goal**: Understand impact of COVID-19 mitigations in Virginia
- **Approach:**
  - Calibrate explanatory mechanistic model to observed cases
  - Project based on scenarios for next 4 months
  - Consider a range of possible mitigation effects in "what-if" scenarios
- **Outcomes:**
  - Ill, Confirmed, Hospitalized, ICU, Ventilated, Death
  - Geographic spread over time, case counts, healthcare burdens

Key Takeaways

Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

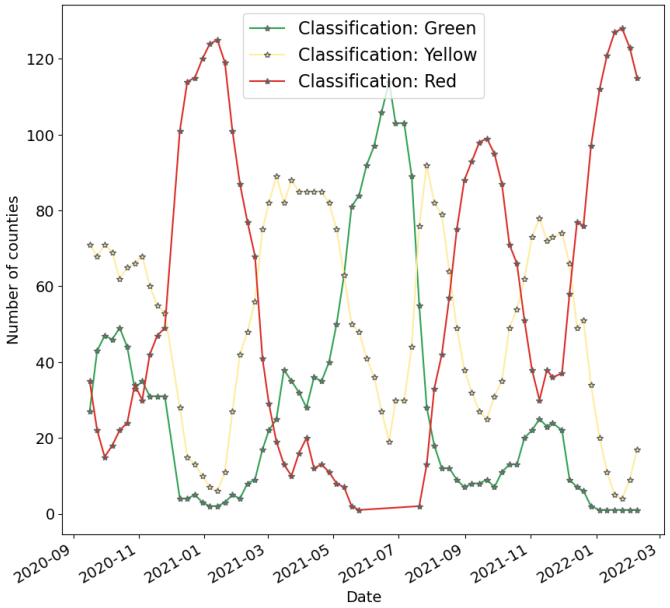
- **Case rates and hospitalizations continue to dramatic decline**
- VA 7-day mean daily case rate is sharply down to 44/100K from 63/100K
  - US is also considerably down to 46/100K (from 72/100K)
- Projections anticipate continued declines:
  - Emerging BA2 subvariant of Omicron could slow and create a broader slow downward in coming weeks
  - Rapidity decline and final level of decline depends on degree of protection to Omicron garnered by previous Omicron infection
- Recent model updates:
  - Further evaluation of dynamics of Omicron immune evasion, roughly align with estimates from VDH
  - Continued refinements to multi-tiered and multi-variant model structure to better capture protections yielded against future infections and other outcomes based on immune histories

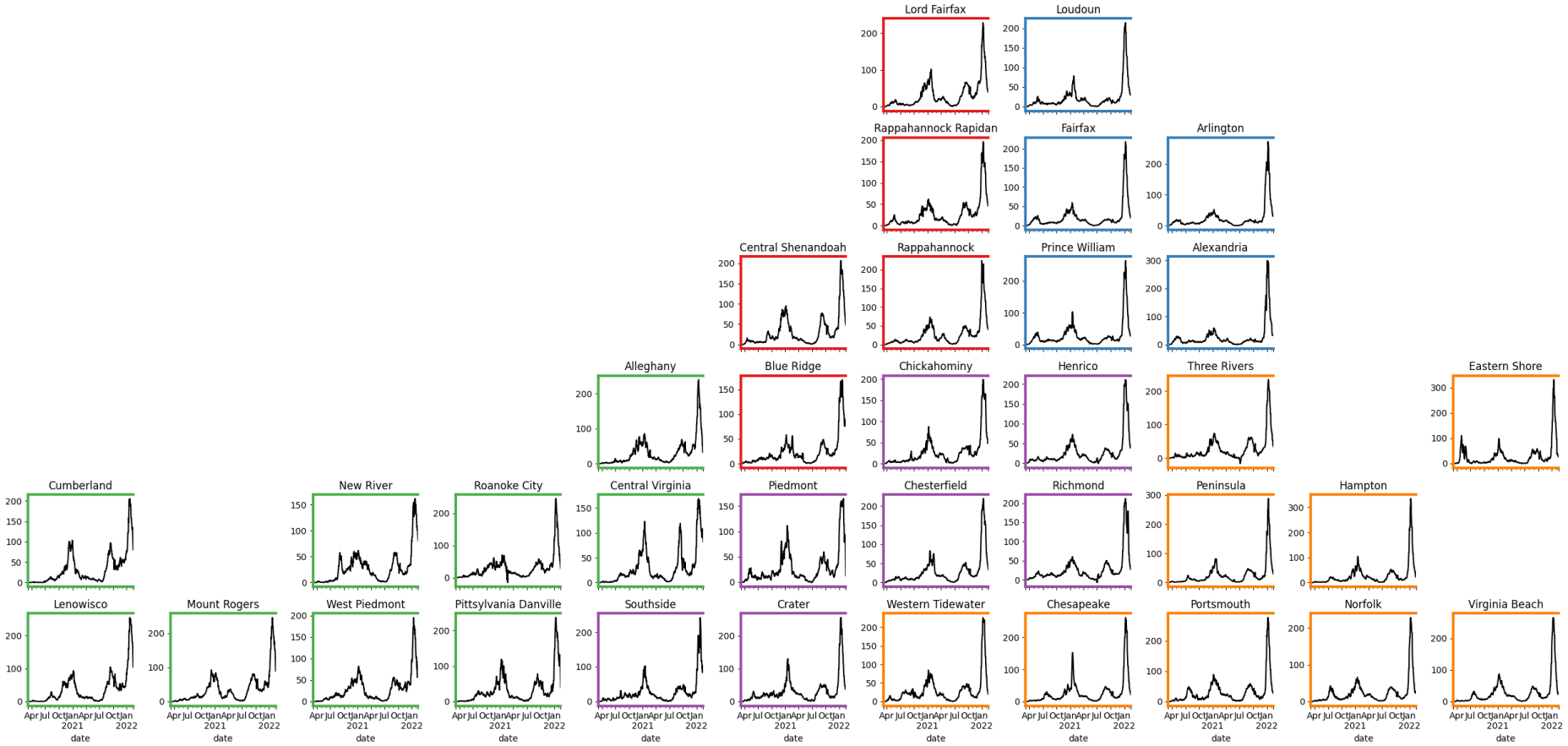
The situation continues to change. Models continue to be updated regularly.

Situation Assessment

Case Rates (per 100k) and Test Positivity

Data source: https://data.cms.gov/covid-19/covid-19-nursing-home-data





County level RT-PCR test positivity

Green: <5.0% (or <20 tests in past 14 days)

Yellow: 5.0%-10.0% (or <500 tests and <2000 tests/100k and >10% positivity over 14 days)

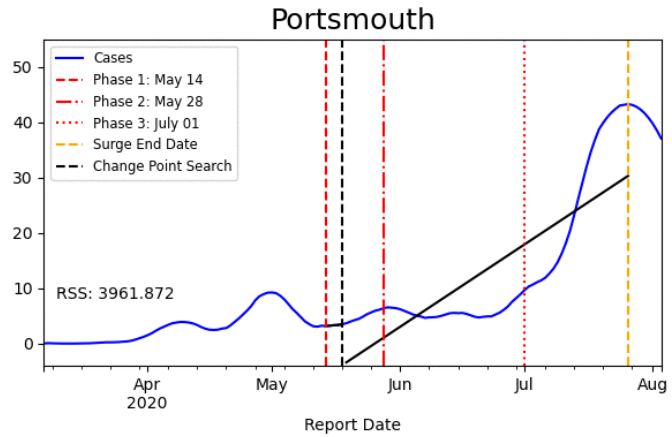
Red: >10.0% (and not "Green" or "Yellow")

District Trajectories

Goal: Define epochs of a Health District's COVID-19 incidence to characterize the current trajectory

Method: Find recent peak and use hockey stick fit to find inflection point afterwards, then use this period's slope to define the trajectory

Hockey stick fit

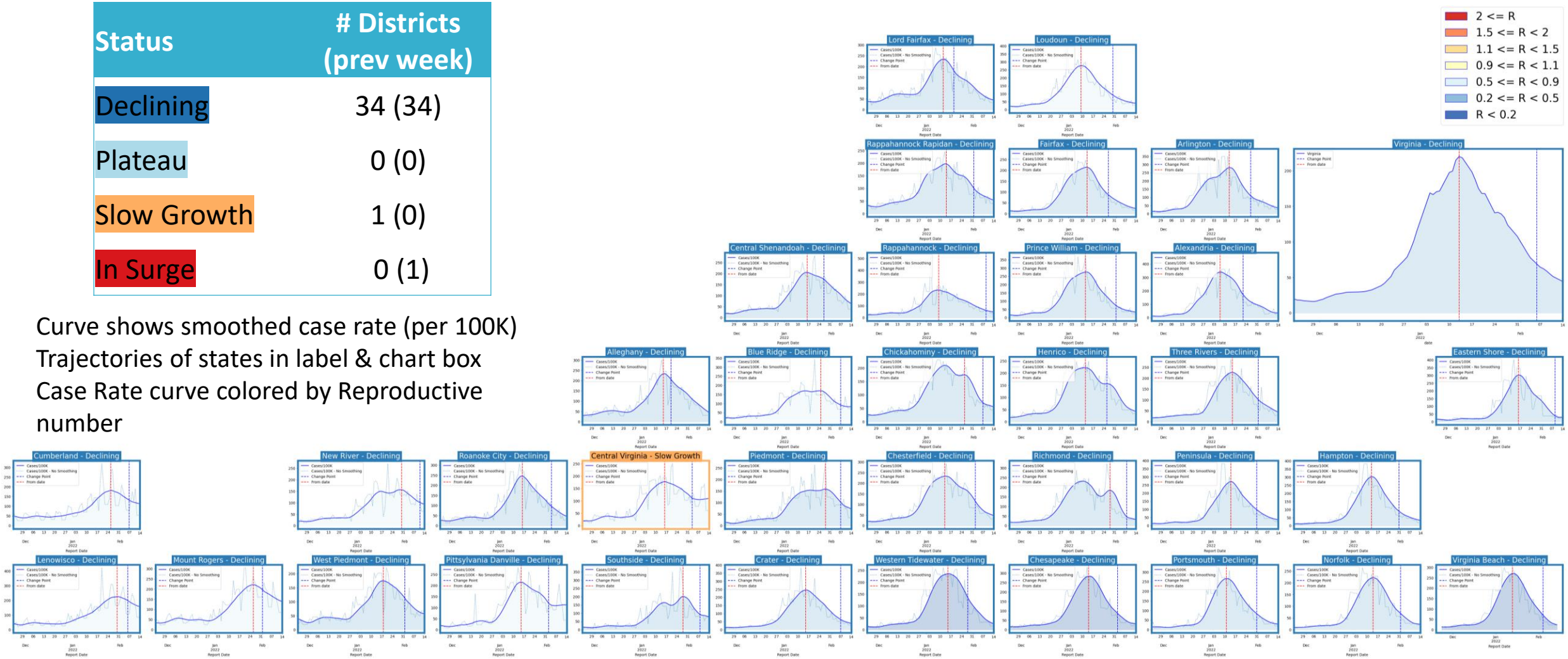


Trajectory	Description	Weekly Case Rate (per 100K) bounds	# Districts (prev week)
Declining	Sustained decreases following a recent peak	below -0.9	34 (34)
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5	0 (0)
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5	1 (0)
In Surge	Currently experiencing sustained rapid and significant growth	2.5 or greater	0 (1)

District Trajectories – last 10 weeks

Status	# Districts (prev week)
Declining	34 (34)
Plateau	0 (0)
Slow Growth	1 (0)
In Surge	0 (1)

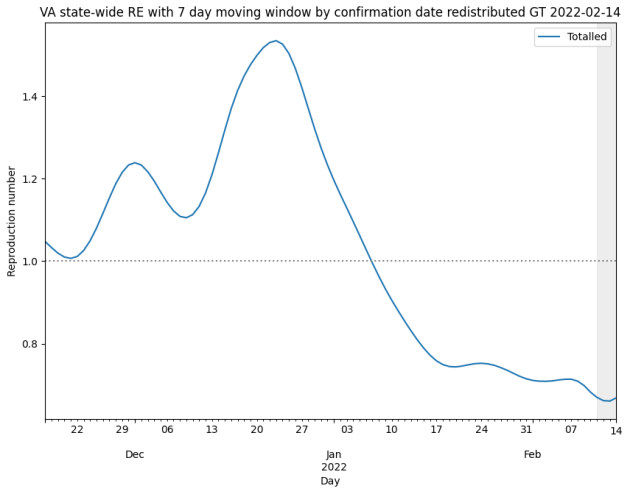
Curve shows smoothed case rate (per 100K)
Trajectories of states in label & chart box
Case Rate curve colored by Reproductive number

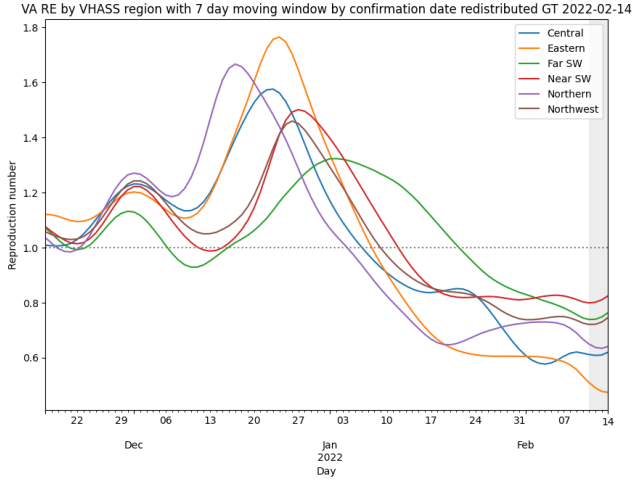


Estimating Daily Reproductive Number – Redistributed gap

Feb 14th Estimates

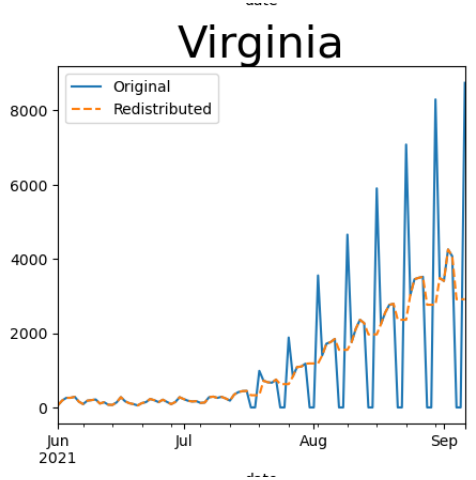
Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.666	0.090
Central	0.617	0.209
Eastern	0.473	0.031
Far SW	0.764	-0.028
Near SW	0.825	0.051
Northern	0.641	0.019
Northwest	0.744	0.036





Skipping Weekend Reports & holidays biases estimates

Redistributed "big" report day to fill in gaps, and then estimate R from "smoothed" time series



Methodology

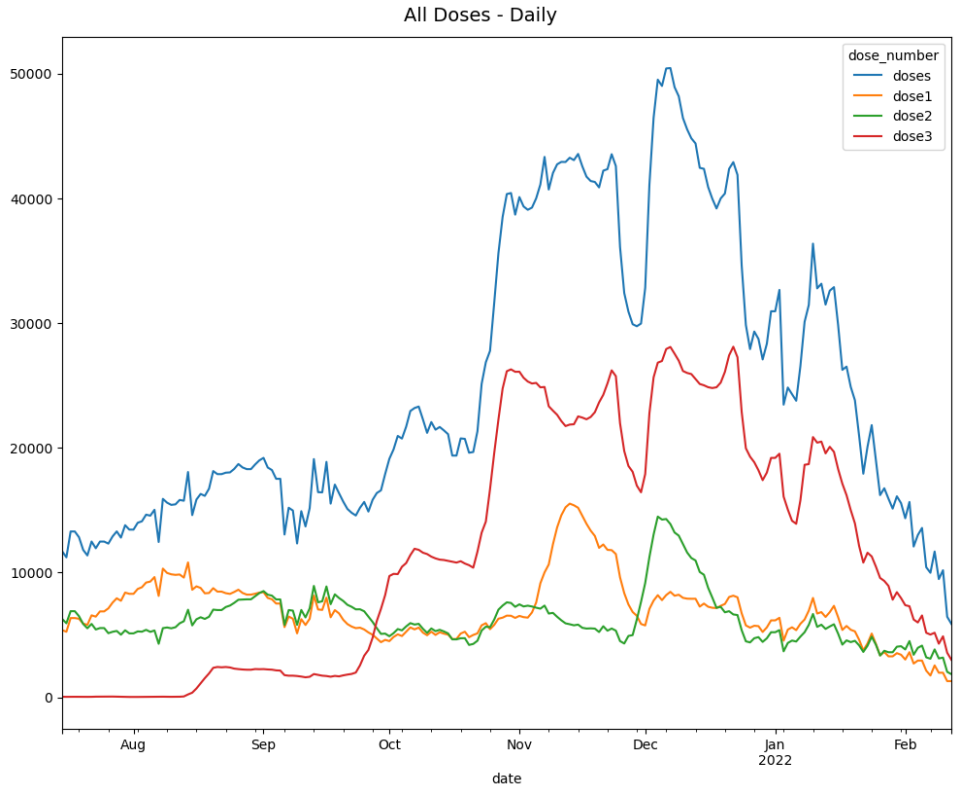
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

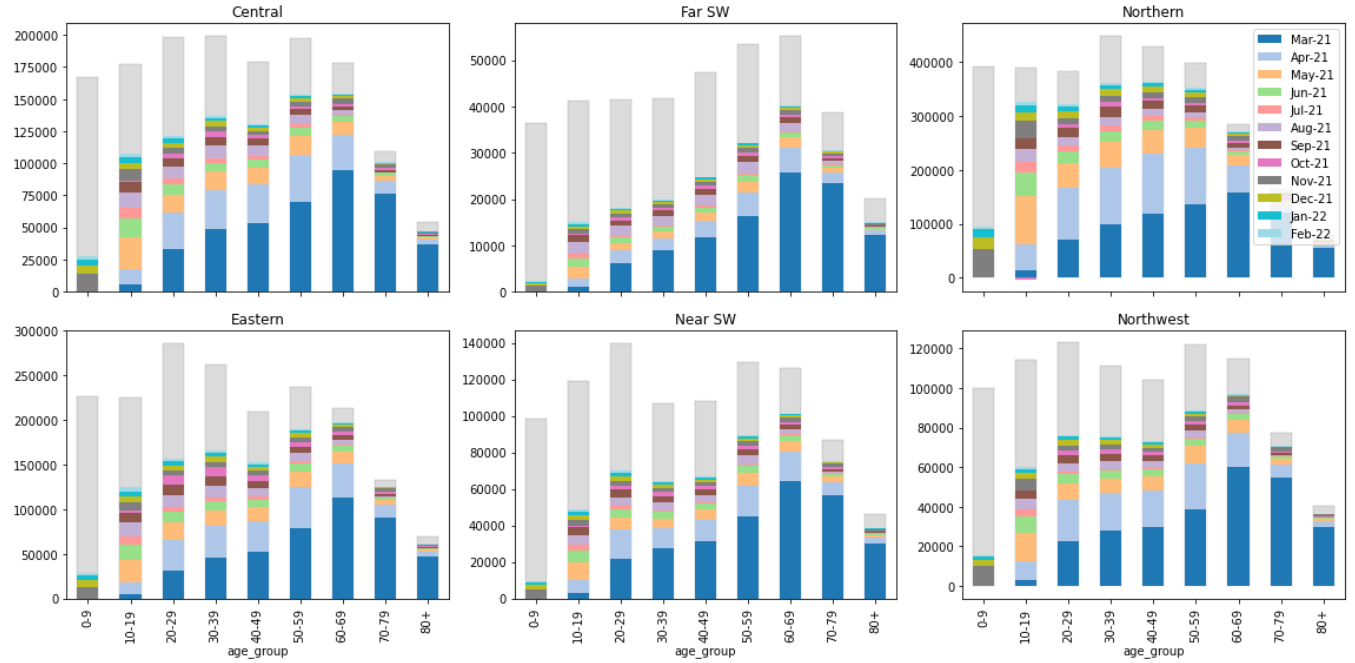
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

Vaccination Administration in Virginia

Vaccine Doses administered:

- Doses administered rates approach levels first experienced when vaccines were first available
- Considerable reduction in vaccination rate experienced since mid-January
- Third dose administration outpaces 1st dose



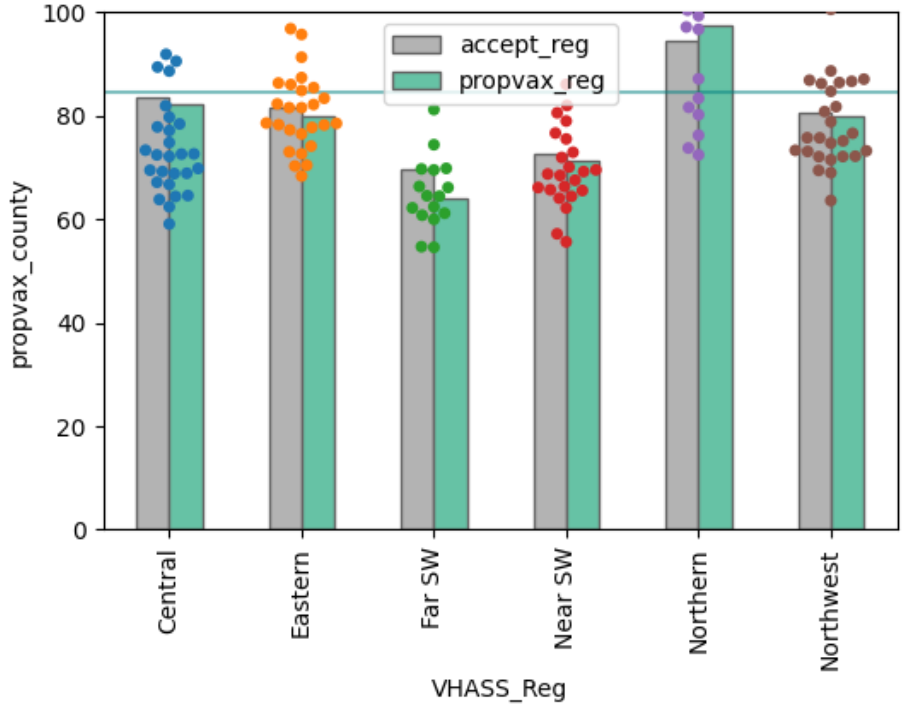


Vaccination Acceptance by Region

Corrections to surveys:

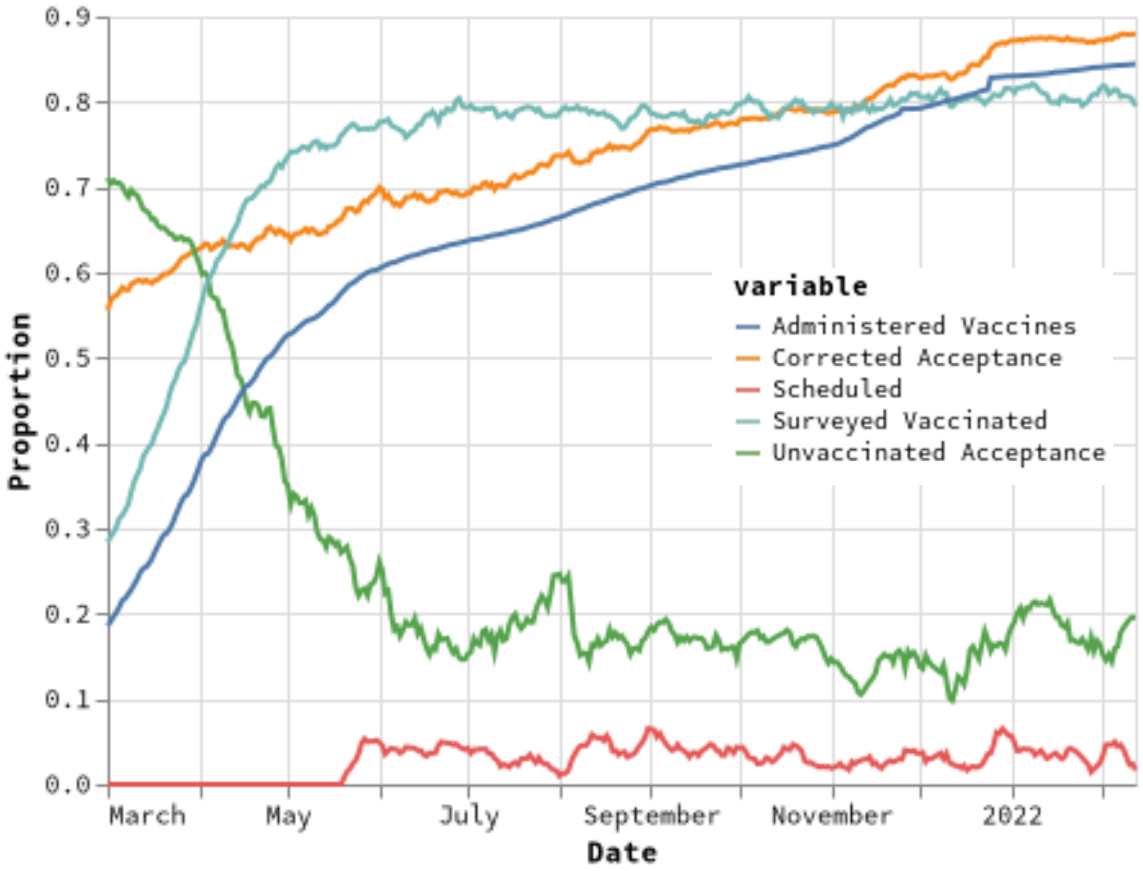
- Facebook administered survey is timely and broad, but biased by who accesses Facebook and answers the survey
- Correction approach:
  - Calculate an over-reporting fraction based on reported vaccinations compared to VDH administration data
  - Cross-validate coarse corrections against HPS survey at the state level and corrected in same manner

Region	COVIDcast accepting corrected	VDH proportion pop vaccinated
Central	85%	82%
Eastern	83%	80%
Far SW	73%	64%
Near SW	77%	71%
Northern	98%	97%
Northwest	84%	80%
Virginia	**87%**	**84%**



Grey Bar: Survey measured and corrected acceptance
Green Bar: Proportion of eligible population administered a vaccine
Dots: Proportion administered at least one dose for each county

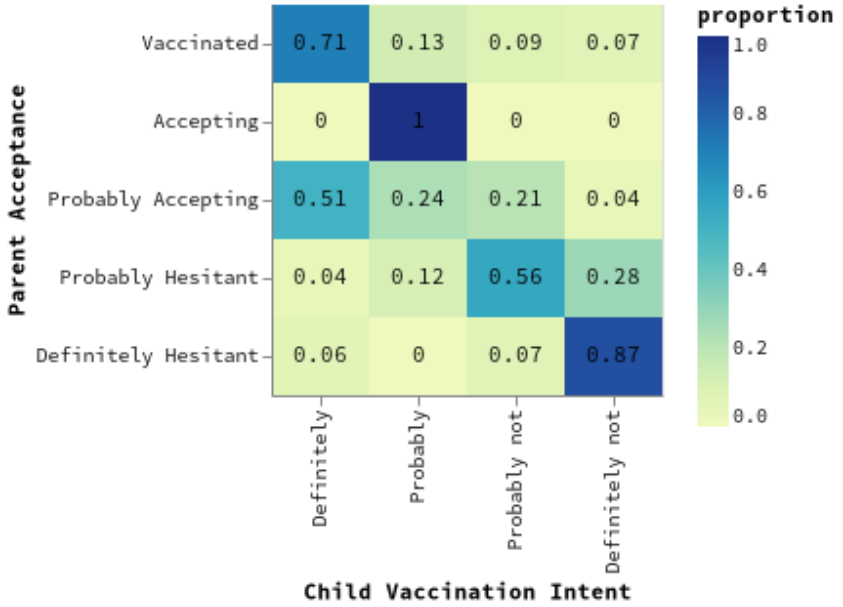
Vaccine Acceptance Components over Time



Vaccine Acceptance adjusted to include scheduled appointments

- Steady rise in acceptance over the past couple months
- Unvaccinated Acceptance shows ~20% of those who are unvaccinated are definitely or probably willing to be vaccinated

Intent to Vaccinate Children Based on Parent's Acceptance Level

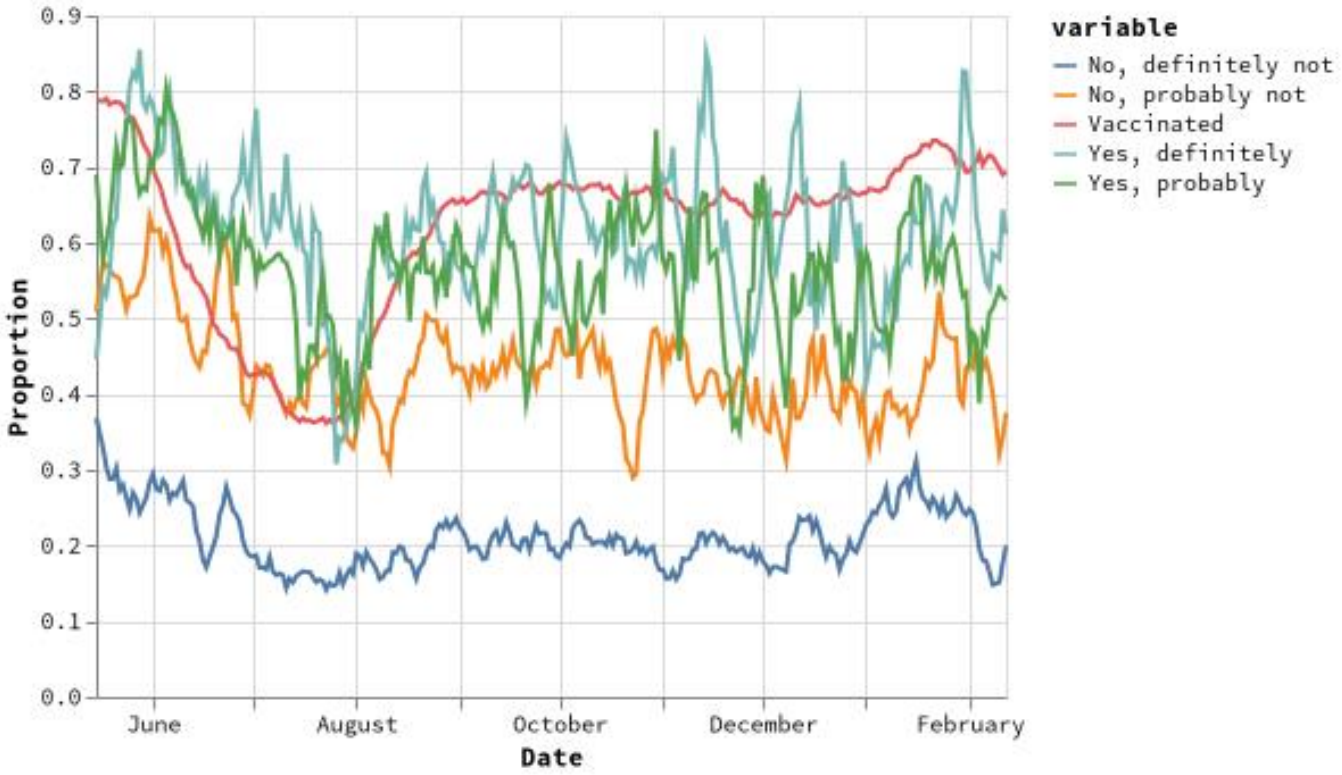


Data Source: https://covidcast.cmu.edu

Mask Usage Slows and Continues Decline

Self-reported mask usage seems to be receding back to ~65%

- US and VA experienced similar decreases
- Mask wearing remains lower amongst unvaccinated especially among least willing to be vaccinated



Data Source: https://covidcast.cmu.edu

SARS-CoV2 Variants of Concern

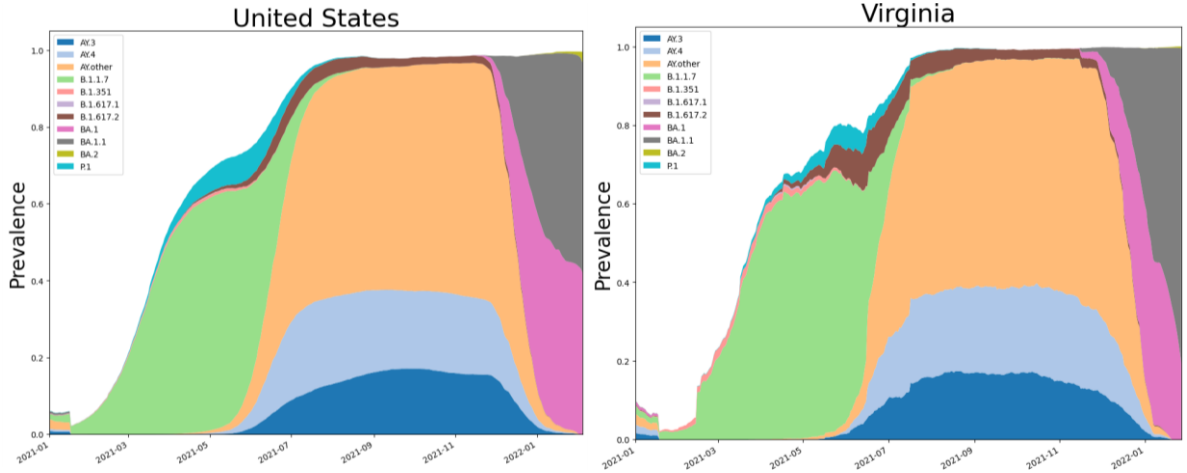
Emerging new variants will alter the future trajectories of pandemic and have implications for future control

- Emerging variants can:
  - Increase transmissibility
  - Increase severity (more hospitalizations and/or deaths)
  - Limit immunity provided by prior infection and vaccinations
- Genomic surveillance remains very limited
  - Challenges ability to estimate impact in US to date and estimation of arrival and potential impact in future

WHO label	Pango lineage*	GISAID clade	Nextstrain clade	Additional amino acid changes monitored*	Earliest documented samples	Date of designation
Alpha	B.1.1.7	GRY	20I (V1)	+S:484K +S:452R	United Kingdom, Sep-2020	18-Dec-2020
Beta	B.1.351	GH/501Y.V2	20H (V2)	+S:L18F	South Africa, May-2020	18-Dec-2020
Gamma	P.1	GR/501Y.V3	20J (V3)	+S:681H	Brazil, Nov-2020	11-Jan-2021
Delta	B.1.617.2	G/478K.V1	21A, 21I, 21J	+S:417N +S:484K	India, Oct-2020	VOI: 4-Apr-2021 VOC: 11-May-2021
Omicron*	B.1.1.529	GRA	21K, 21L	+R346K	Multiple countries, Nov-2021	VUM: 24-Nov-2021 VOC: 26-Nov-2021

World Health Organization [WHO](#)

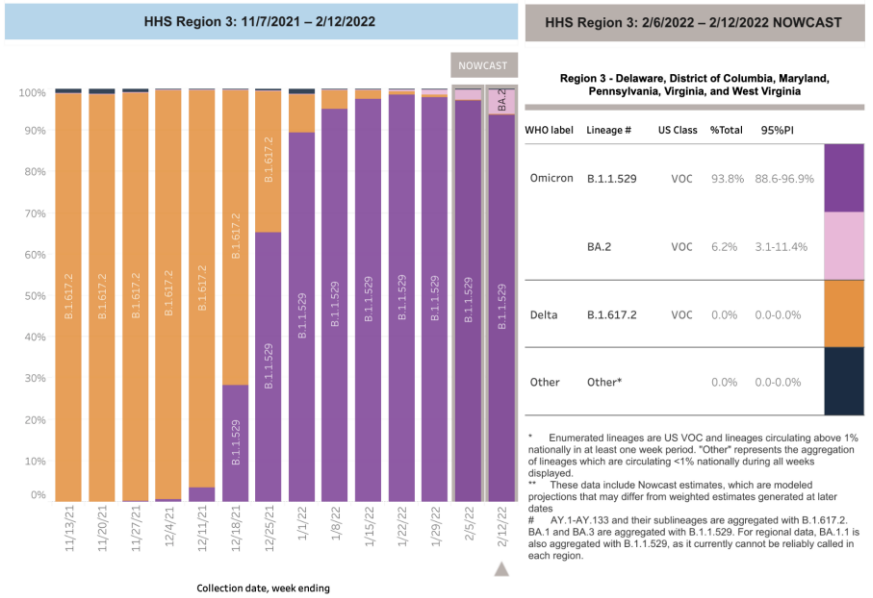
GISAID outbreak.info



Omicron Prevalence
CDC now tracking subvariant BA2

CDC nowcast for week ending Feb 12th shows 6.2% BA.2 in Region 3, up from 2.7% previous week

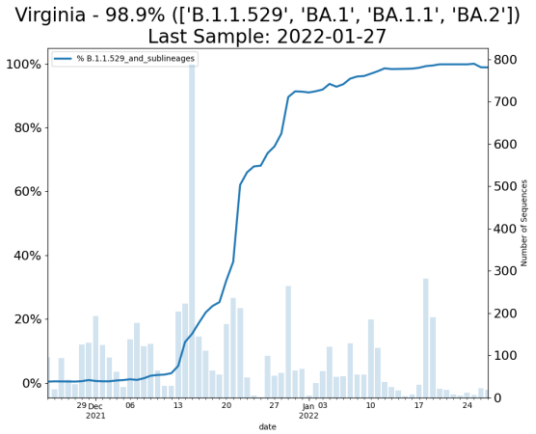
Now all other VOCs are at 0.00%

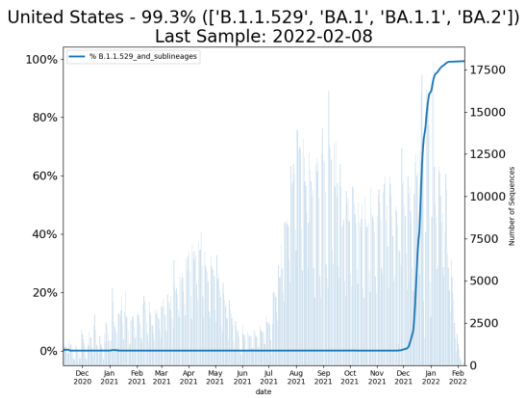


CDC [CDC Variant Tracking](#)

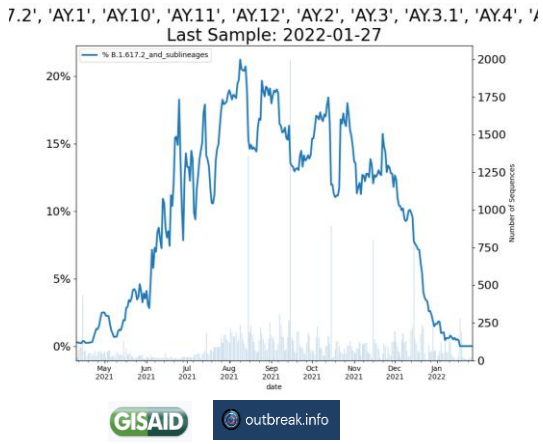
SARS-CoV2 Variants of Concern

Omicron ο - Lineage B.1.1.529



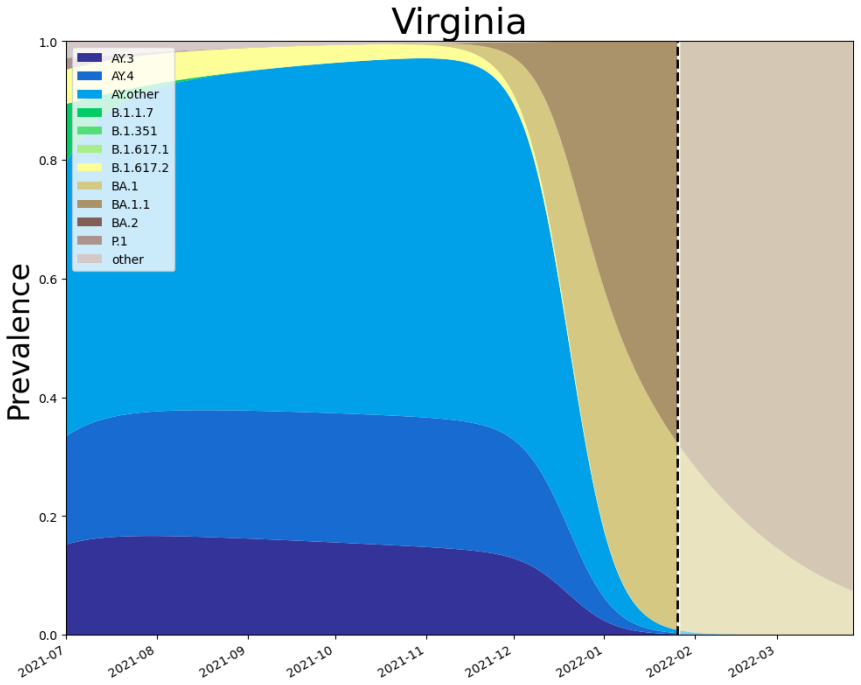


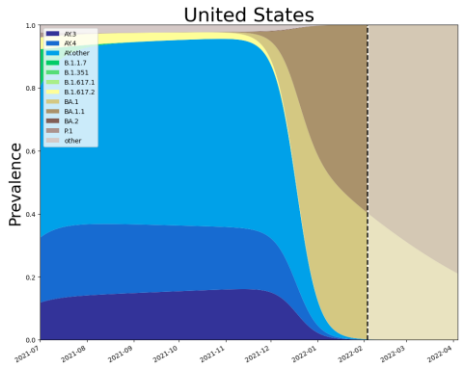
Delta δ - Lineage B.1.617.2



GISAID outbreak.info

VoC Polynomial Fit Projections

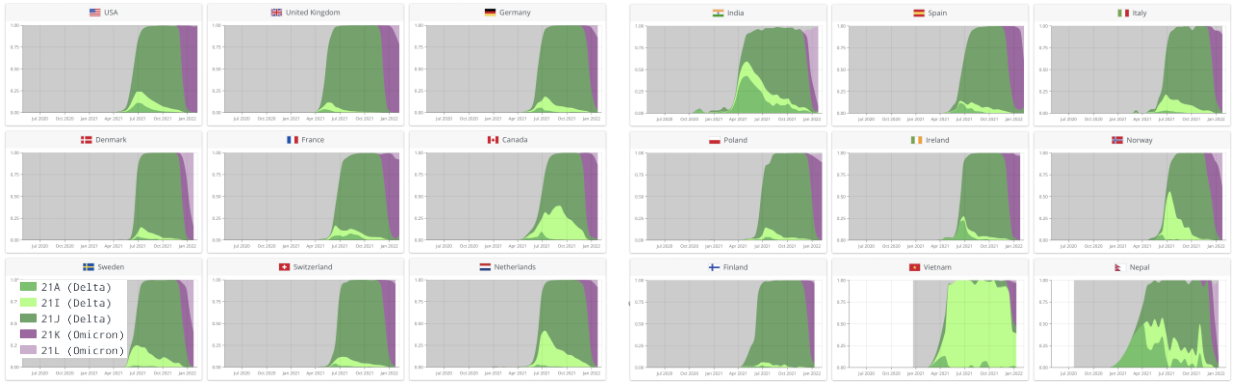




SARS-CoV2 BA.2 subvariant Tracking

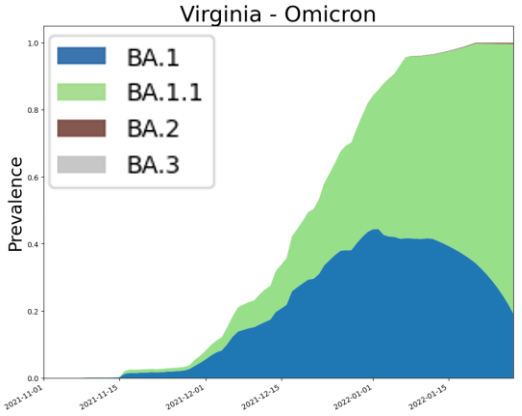
BA.2 subvariant growing rapidly in some European countries

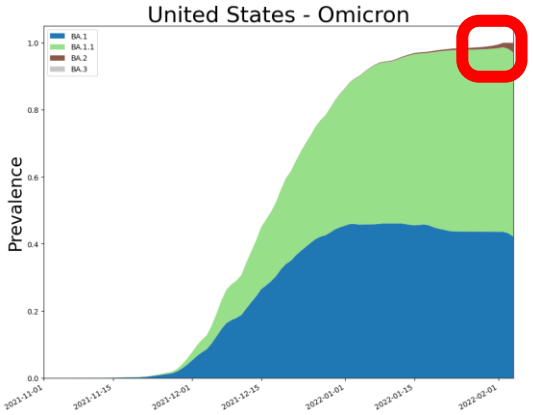
- Both Delta and the Omicron BA.2 subvariant don't have the SGTF signal with PCR tests, so the reduction caused by Omicron BA.1 SGTF can be an imperfect signal for increased BA.2
- Subvariant BA.2 in all HHS regions of USA, Region 3 (includes VA) has highest estimated prevalence
- BA.2 is now majority subvariant in most northern European countries and India and some neighbors



CoVariants.org

Whole Genomes in public repositories

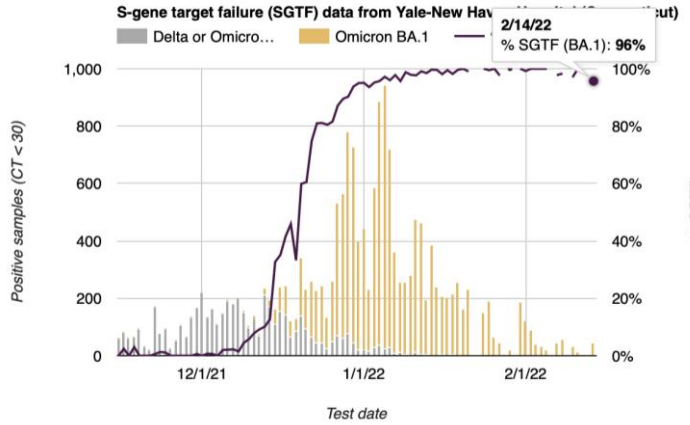




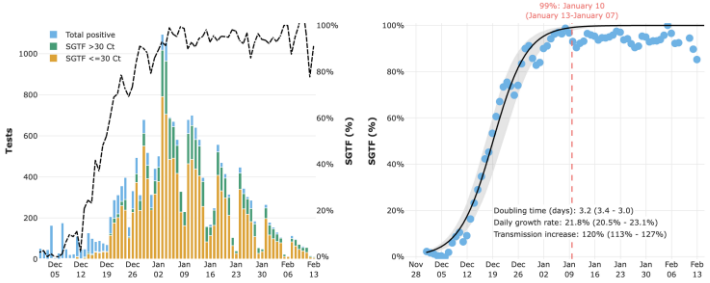
GISAID outbreak.info

SGTF proxy in US

Yale- New Haven



San Diego



Some drops in SGTF in CT and CA

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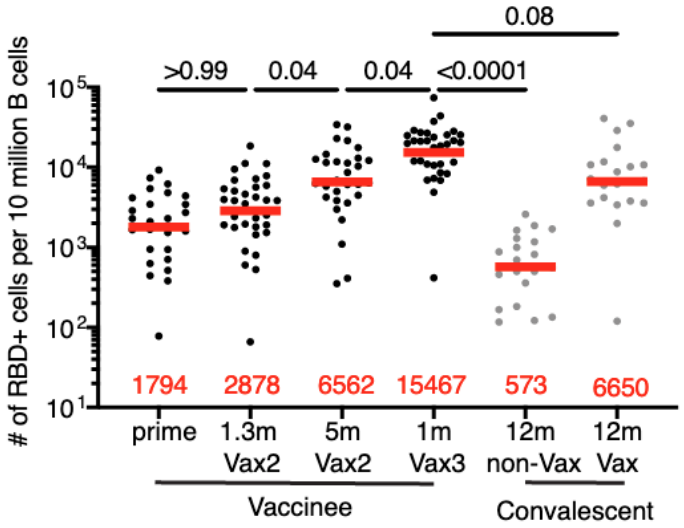
Pandemic Pubs

1. A 3rd mRNA vaccine is shown to cause rapid recall and expanded/diversified memory B cell repertoire. A key mechanism that contributes to the enhanced protection against severe disease by boosters even when neutralizing antibody isn't sufficient to prevent infection.
2. Tokyo experiments indicate BA.2 is more pathogenic than BA.1 in animal model and BA.2 is more replicative in human nasal epithelial cells.
3. UKHSA estimates shorter serial interval for BA.2. Possible contribution to growth advantage and increasing prevalence.
4. MMWR study looks at the Omicron wave's impact on children, demonstrating that this "more mild" disease caused significant morbidity in children, especially the 0-4 year olds

1



For n=43 individuals Individuals that received a 3rd vaccine dose developed significantly increased numbers of RBD-binding memory cells compared to the 2nd dose or naturally infected individuals
https://www.biorxiv.org/content/10.1101/2022.02.14.480394v1

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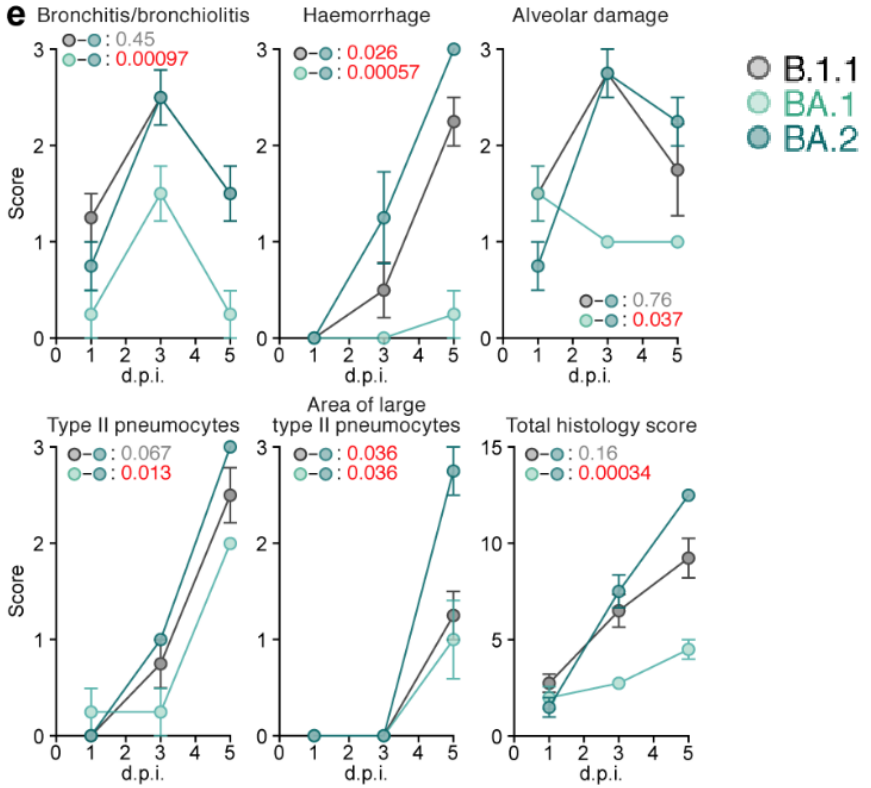

Researchers in Tokyo investigated the dynamics of viral replication of BA.2 in vivo through hamster infection experiments. All histopathological parameters including bronchitis/bronchiolitis, haemorrhage, alveolar damage, and the levels of type II pneumocytes, of BA.2-infected hamsters were significantly higher than those in BA.1
https://www.biorxiv.org/content/10.1101/2022.02.14.480335v1

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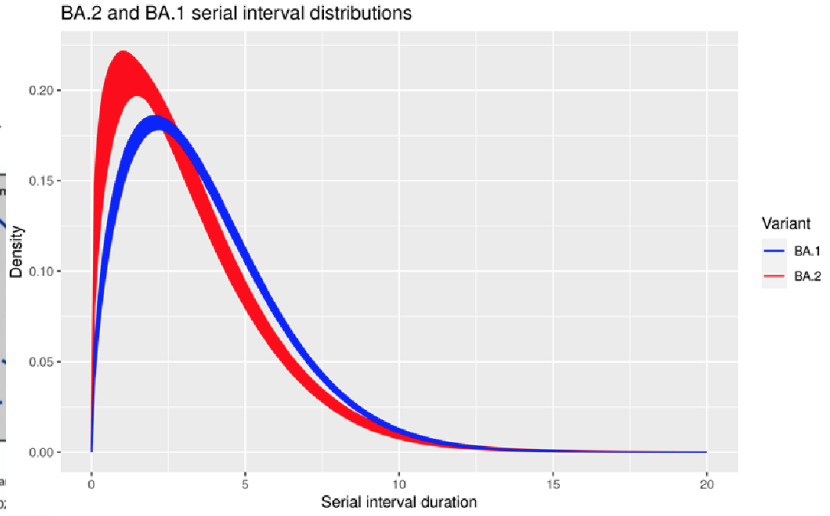

UKHSA estimates that the mean serial interval for BA.2 is 3.27 days compared to BA.1 3.72 days. The serial interval suggests the time between primary and secondary infections is shorter.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1054357/Technical-Briefing-36-11February2022_v2.pdf
https://twitter.com/corneliusroemer/status/1492434232664375304

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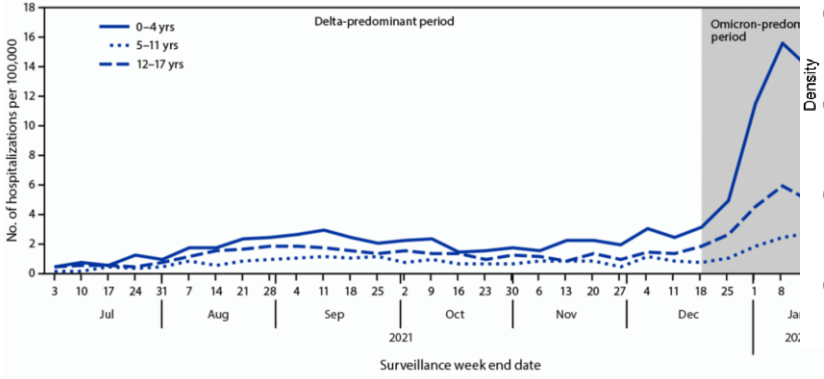
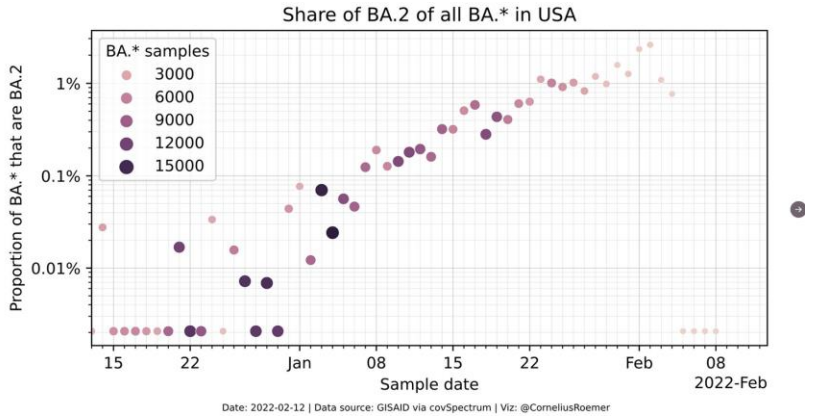
FIGURE. Weekly COVID-19–associated hospitalization rates* among children and adolescents aged 0–17 years, by age group — COVID-NET, 14 states,† July 3, 2021–January 22, 2022



MMWR study from CDC illustrates the burden of increased transmission on children, especially the very young who are ineligible for vaccination.
https://www.cdc.gov/mmwr/volumes/71/wr/mm7107e4.htm?s_cid=mm7107e4_w

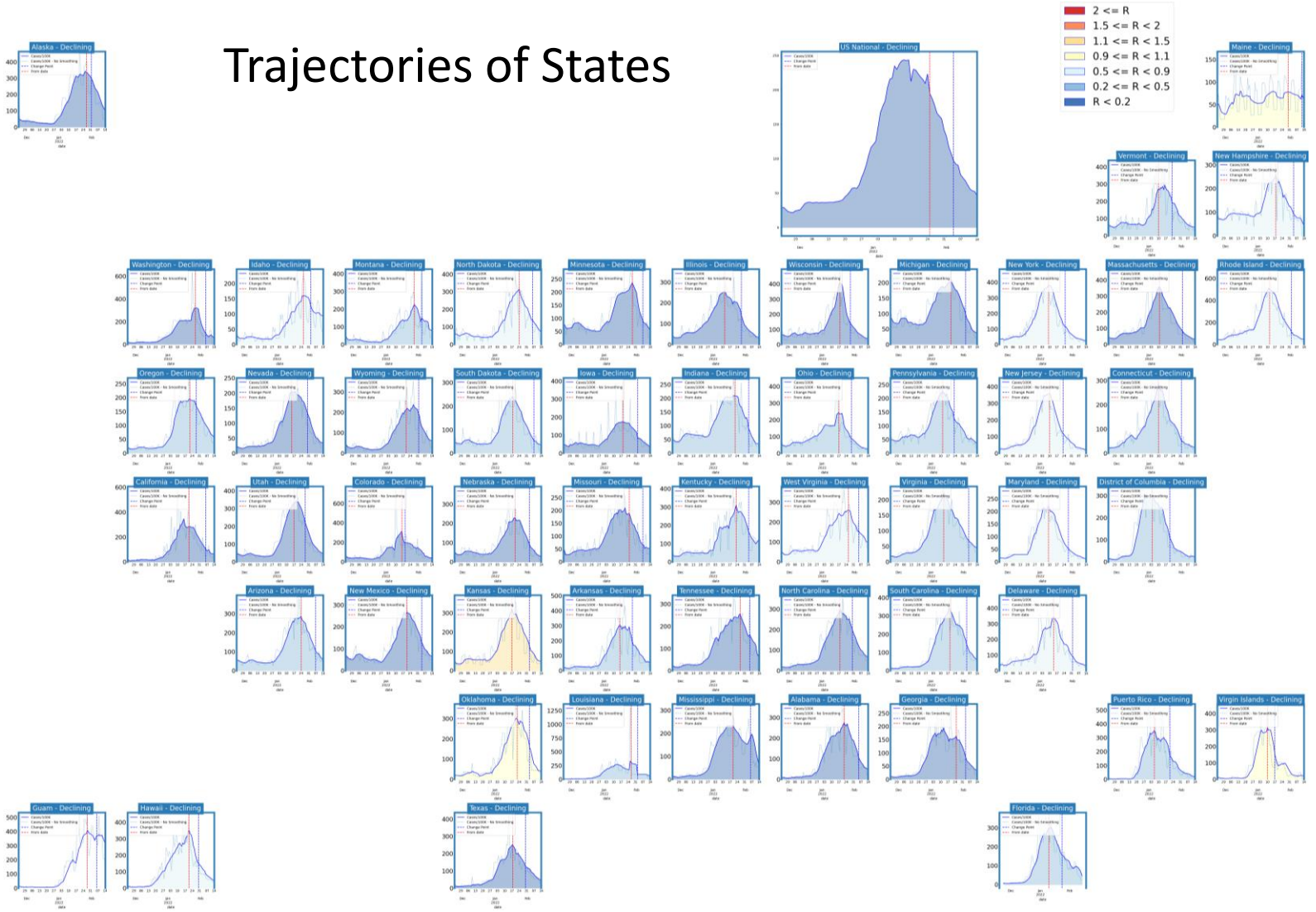


United States Case Rates

- Most of nation has shifted to a declining trajectory
- Growth remains but mainly along the northern border

Status	# States
Declining	54 (54)
Plateau	0 (0)
Slow Growth	0 (0)
In Surge	0 (0)

Trajectories of States



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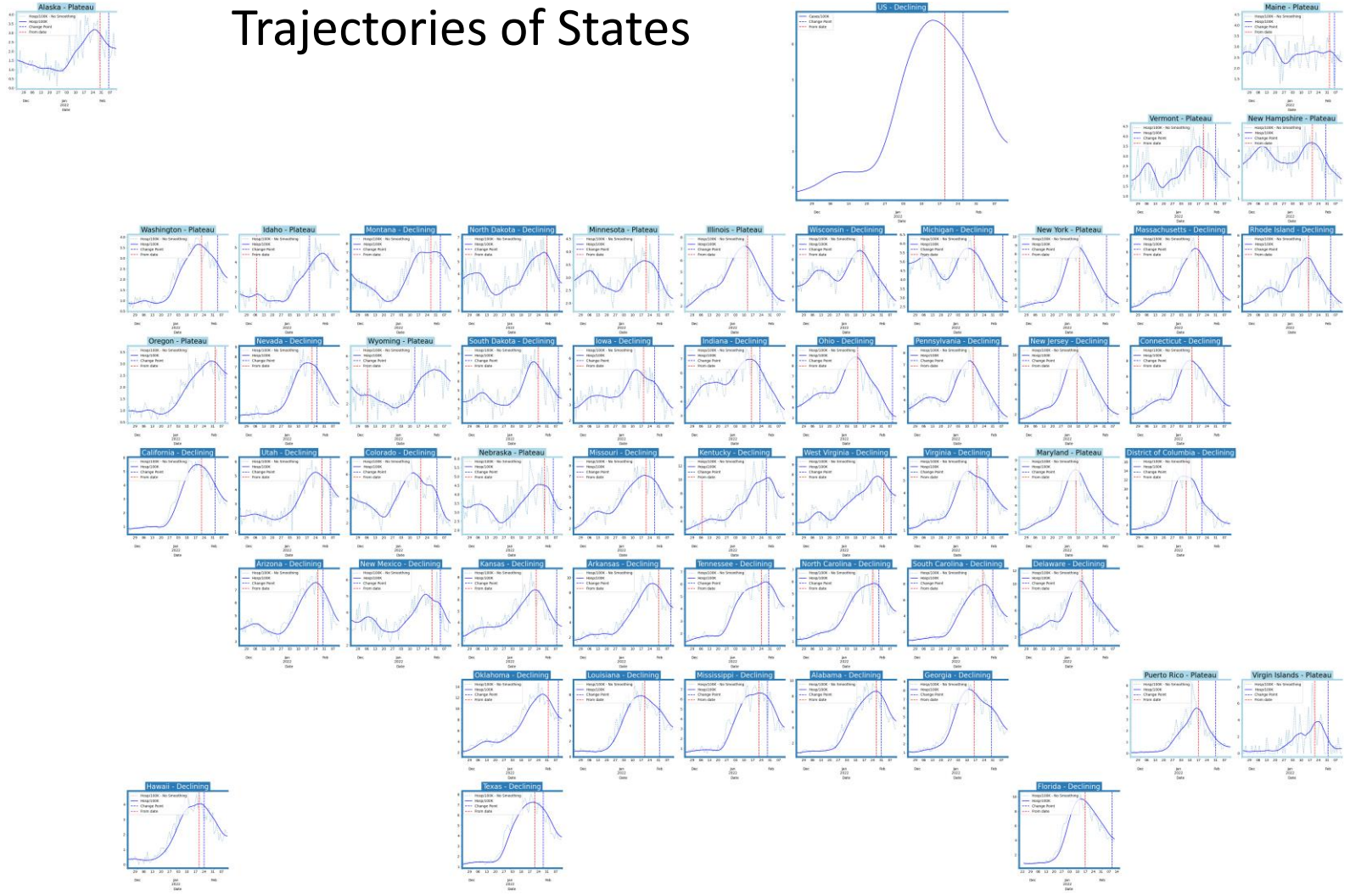
United States Hospitalizations

- Hospital admissions are lagging case rates, but are mixed across the states
- Many states in growth trajectories show signs of slowing

Status	# States
Declining	38 (30)
Plateau	15 (25)
Slow Growth	0 (6)
In Surge	0 (2)

Trajectories of States



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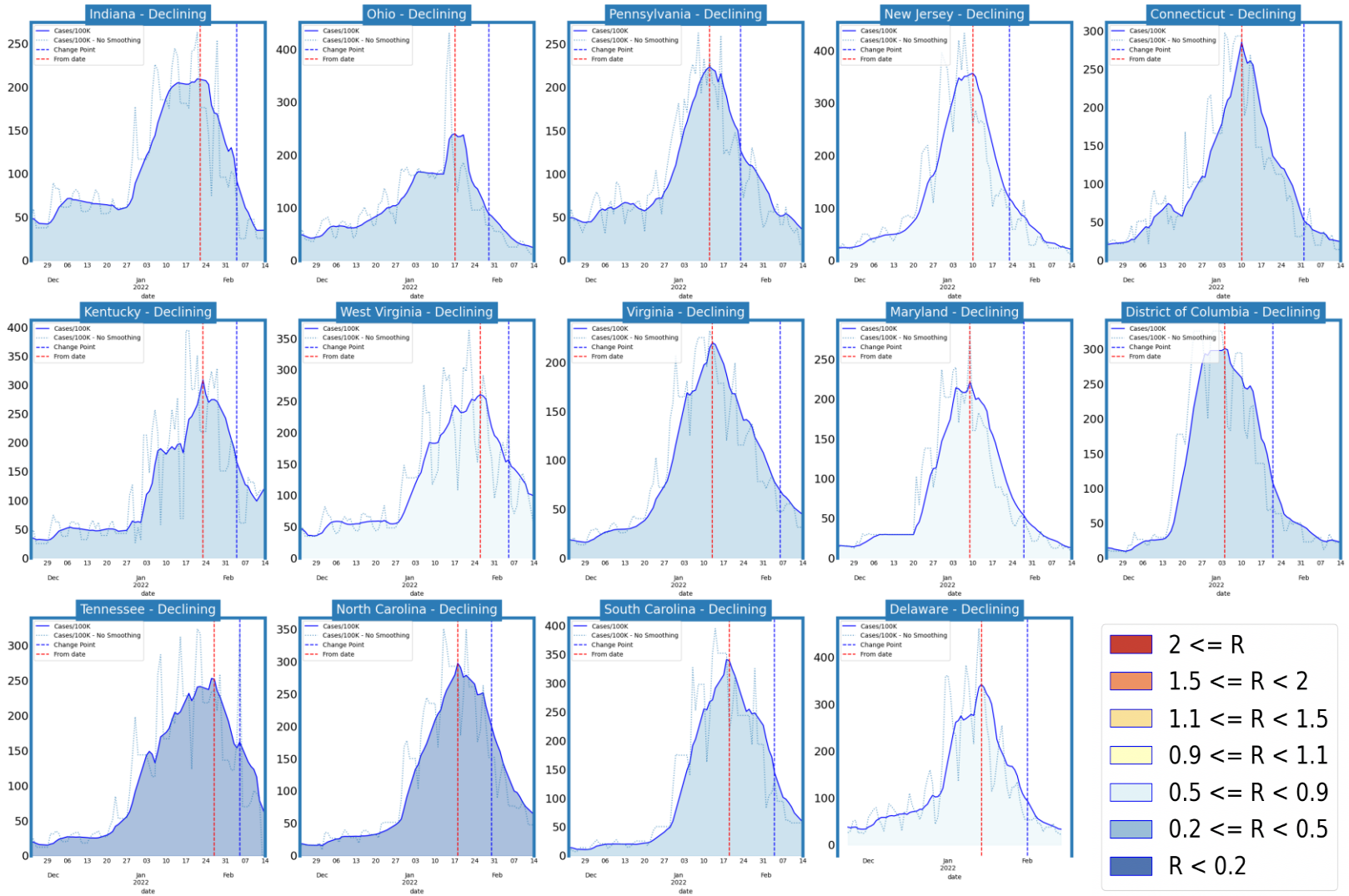
Virginia and Her Neighbors

- All have dramatically dropped from peaks
- Rates remain high, though substantially lower
- Neighbors to west and south remain near or above 50/100K daily incident case rates, whereas to the north and east rates have mainly fallen below 50/100K



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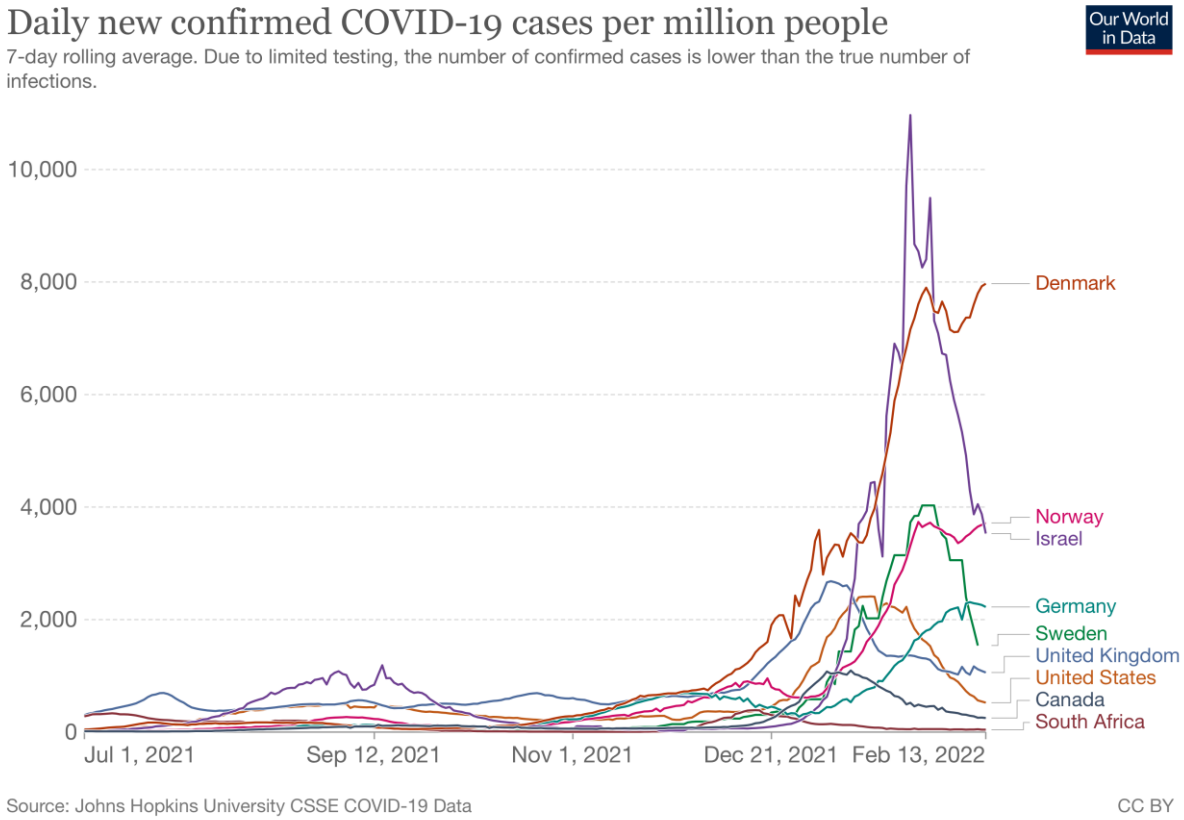
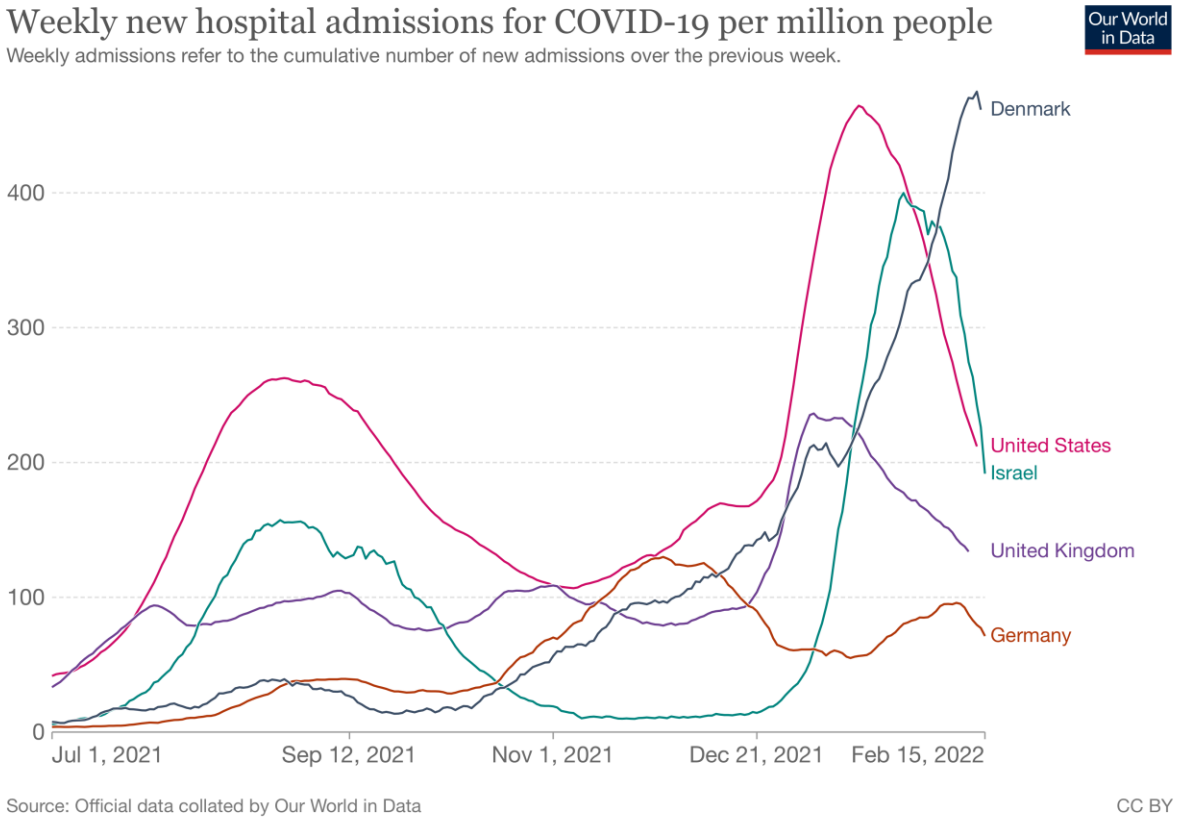
Other Countries

- UK continues to see case rates flattening out, and case rates are very high but flat in Denmark
- US, Israel, Sweden have continued declines start to slow
- US continues per capita hospitalization rates have declined dramatically

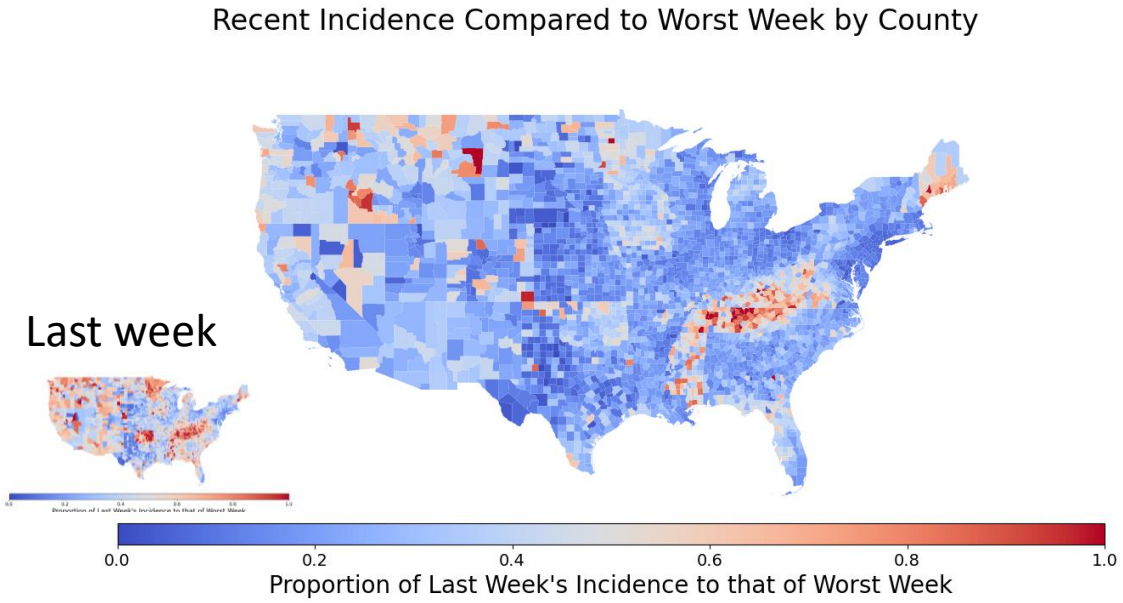


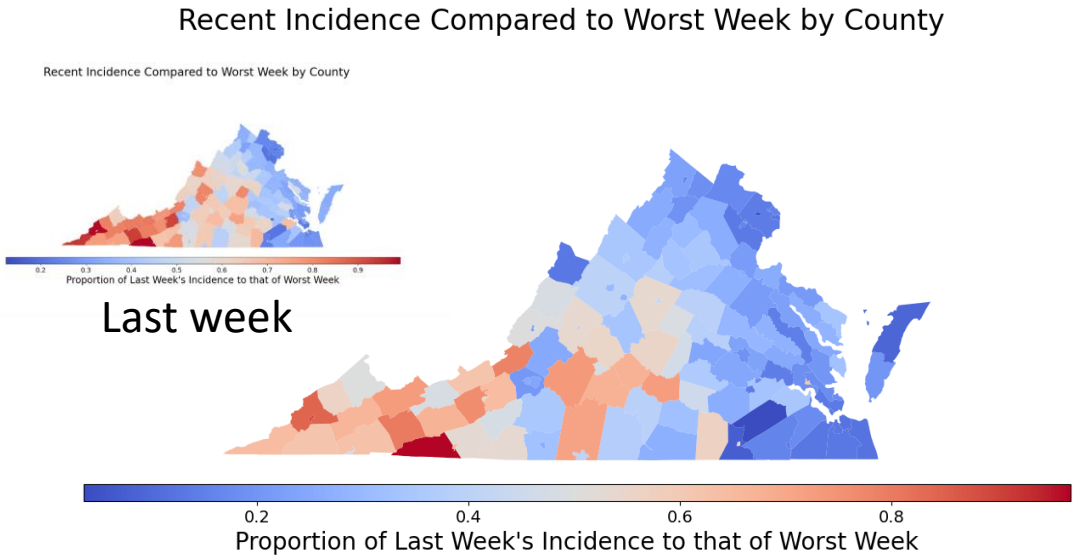


Our World in Data

County-level comparison to previous highest peak

- Most counties in VA have had the highest case rate of the pandemic in the last week
- Nationally the number of counties at their highest rate has expanded considerably





Zip code level weekly Case Rate (per 100K)

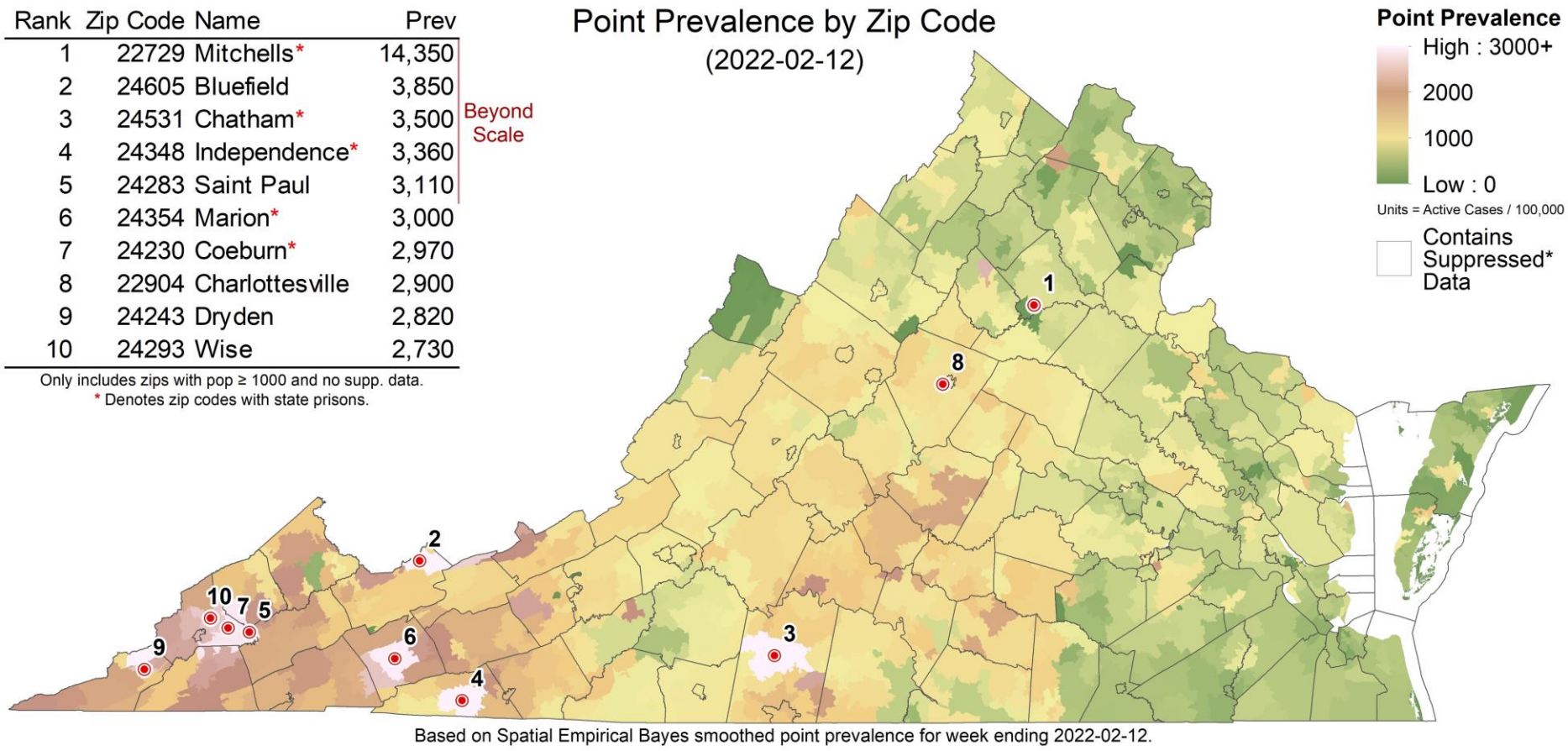
Case Rates in the last week by zip code

- Clusters of high prevalence in Southwest
- Some counts are low and suppressed to protect anonymity, those are shown in white

Rank	Zip Code	Name	Prev
1	22729	Mitchells*	14,350
2	24605	Bluefield	3,850
3	24531	Chatham*	3,500
4	24348	Independence*	3,360
5	24283	Saint Paul	3,110
6	24354	Marion*	3,000
7	24230	Coeburn*	2,970
8	22904	Charlottesville	2,900
9	24243	Dryden	2,820
10	24293	Wise	2,730

Beyond Scale

Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2022-02-12.

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Risk of Exposure by Group Size and HCW prevalence

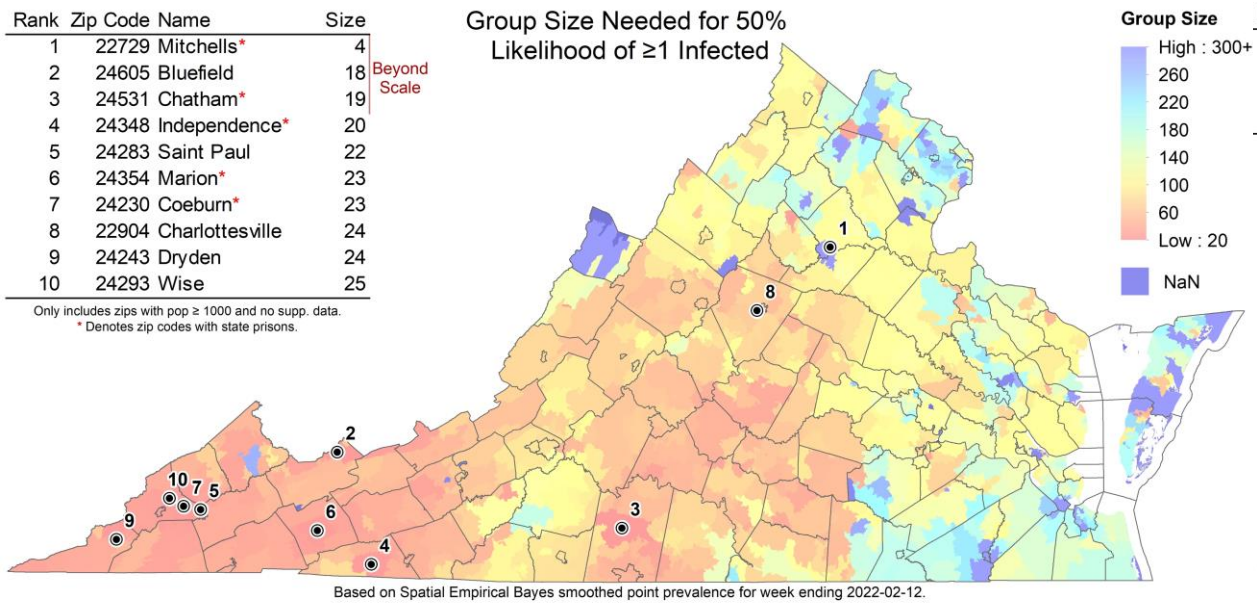
Case Prevalence in the last week by zip code used to calculate risk of encountering someone infected in a gathering of randomly selected people (group size 25)

- **Group Size**: Assumes 2 undetected infections per confirmed case (ascertainment rate from recent seroprevalence survey), and shows minimum size of a group with a 50% chance an individual is infected by zip code (eg in a group of 4 in Mitchells, there is a 50% chance someone will be infected)
- **HCW ratio**: Case rate among health care workers (HCW) in the last week using patient facing health care workers as the denominator / general population's case prevalence

Rank	Zip Code	Name	Size
1	22729	Mitchells*	4
2	24605	Bluefield	18
3	24531	Chatham*	19
4	24348	Independence*	20
5	24283	Saint Paul	22
6	24354	Marion*	23
7	24230	Coeburn*	23
8	22904	Charlottesville	24
9	24243	Dryden	24
10	24293	Wise	25

Beyond Scale

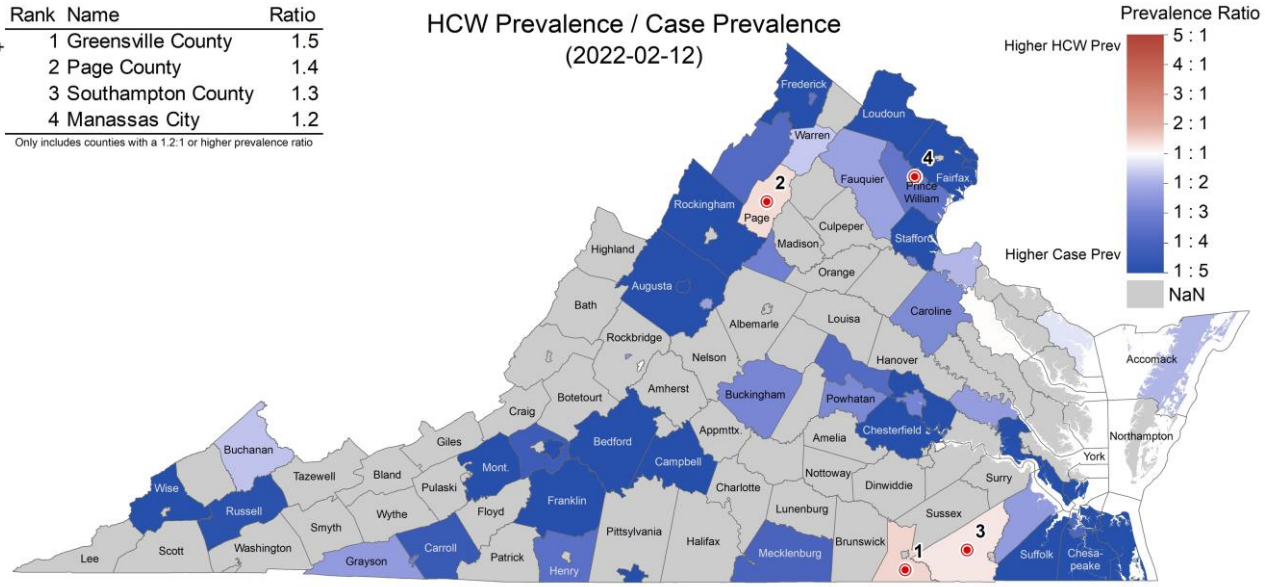
Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2022-02-12.

Rank	Name	Ratio
1	Greensville County	1.5
2	Page County	1.4
3	Southampton County	1.3
4	Manassas City	1.2

Only includes counties with a 1.2:1 or higher prevalence ratio



Current Hot-Spots

Case rates that are significantly different from neighboring areas or model projections

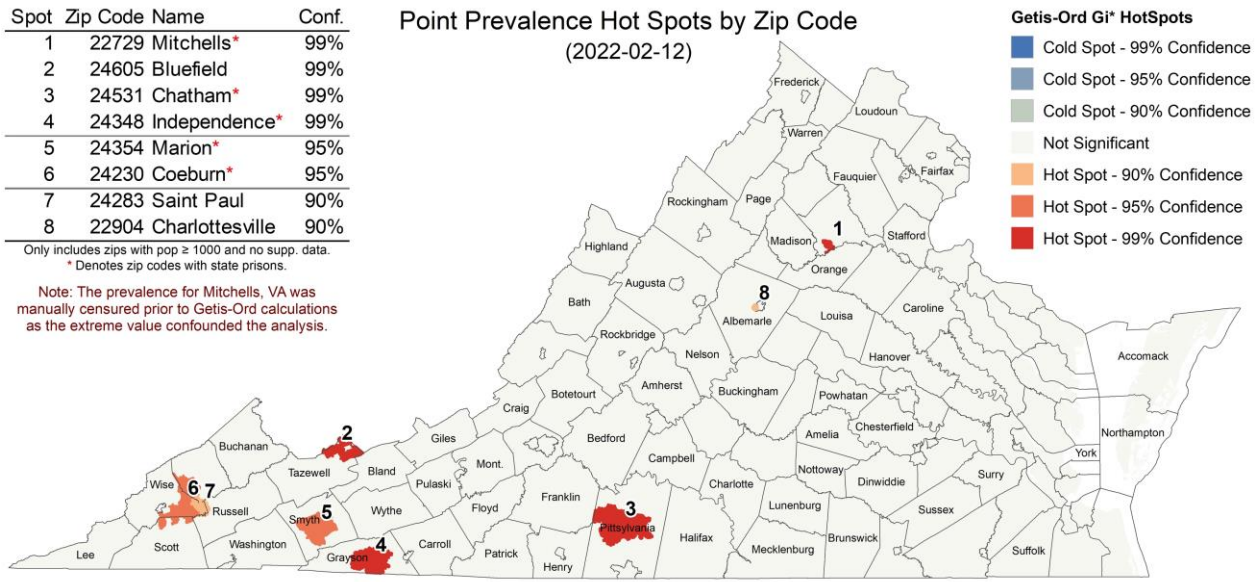
- **Spatial**: Getis-Ord Gi* based hot spots compare clusters of zip codes with weekly case prevalence higher than nearby zip codes to identify larger areas with statistically significant deviations
- **Temporal**: The weekly case rate (per 100K) projected last week compared to observed by county, which highlights temporal fluctuations that differ from the model's projections

Spatial Hotspots

Spot	Zip Code	Name	Conf.
1	22729	Mitchells*	99%
2	24605	Bluefield	99%
3	24531	Chatham*	99%
4	24348	Independence*	99%
5	24354	Marion*	95%
6	24230	Coeburn*	95%
7	24283	Saint Paul	90%
8	22904	Charlottesville	90%

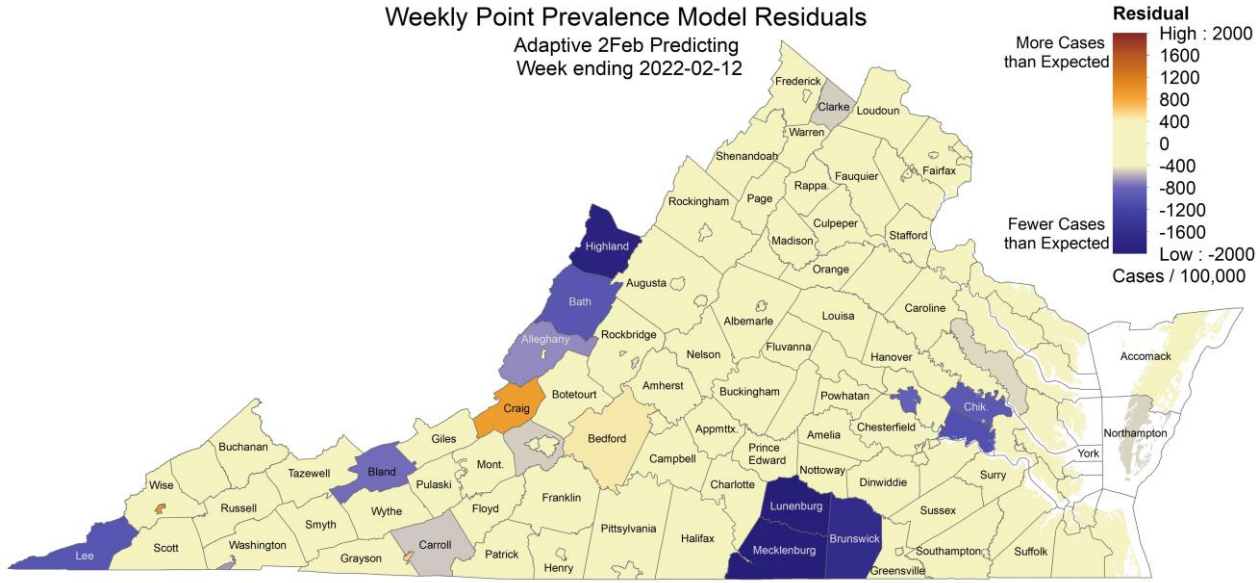
Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.

Note: The prevalence for Mitchells, VA was manually censured prior to Getis-Ord calculations as the extreme value confounded the analysis.



Based on Global Empirical Bayes smoothed point prevalence for week ending 2022-02-12.

Clustered Temporal Hotspots

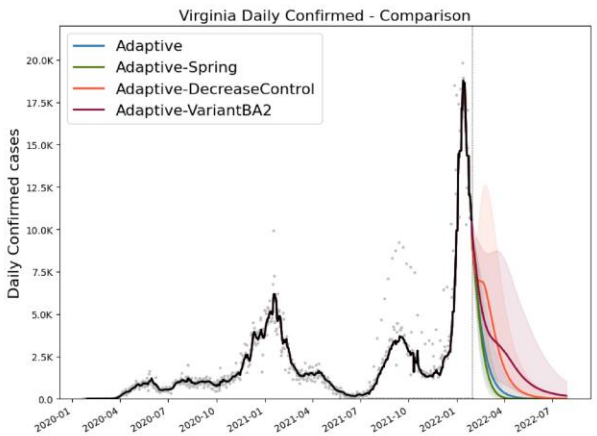


Moran's I = 0.01298, Z-Score = 0.933809, P-Value = 0.350402
No Residual Autocorrelation Detected

Scenario Trajectory Tracking

Which scenario from last projection did each county track closest?

- Majority of counties tracked Adaptive-Spring closest (though is very similar to Adaptive)
- Handful of counties tracked the DecreasedControl and BA2 (mostly areas with hotspots of activity)

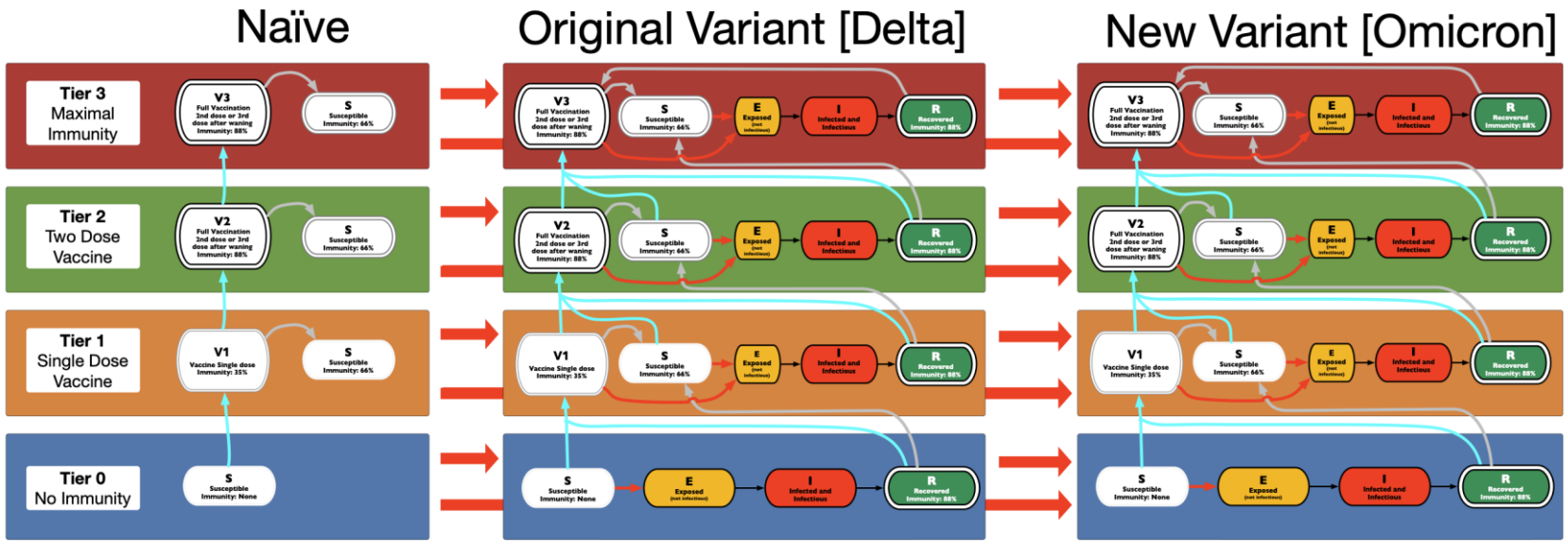


Model Update – Adaptive Fitting

Model Structure Extended for Multiple Strains

Omicron escapes immunity from vaccinated and those infected with Delta

- Multiple strain support allows representation of differential protection based on immunological history
- Severity of Outcomes varies by strain and level of immunity, thus allowing model to better capture hospitalizations and deaths from Omicron
- Adaptive fitting approach continues to use simulation to generate the full distribution of immune states across the population



Adaptive Fitting Approach

Each county fit precisely, with recent trends used for future projection

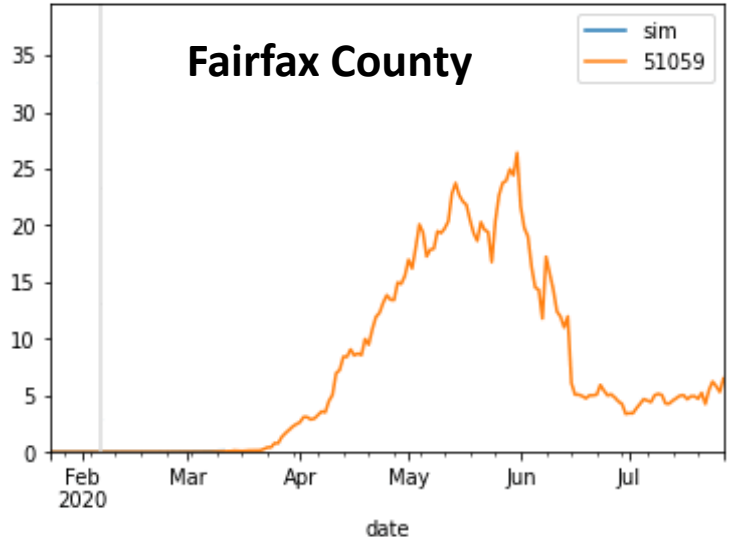
- Allows history to be precisely captured, and used to guide bounds on projections

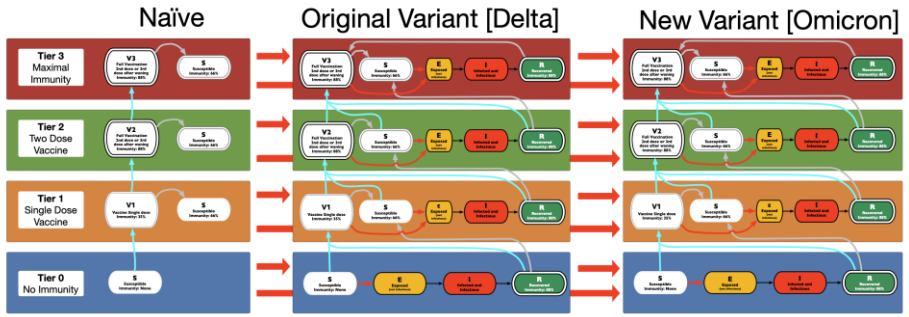
Model: An alternative use of the same meta-population model, PatchSim with multiple tiers of immunity

- Allows for future "what-if" Scenarios to be layered on top of calibrated model
- Allows for waning of immunity and for partial immunity against different outcomes (eg lower protection for infection than death)

External Seeding: Steady low-level importation

- Widespread pandemic eliminates sensitivity to initial conditions, we use steady 1 case per 10M population per day external seeding





Using Ensemble Model to Guide Projections

Ensemble methodology that combines the Adaptive with machine learning and statistical models such as:

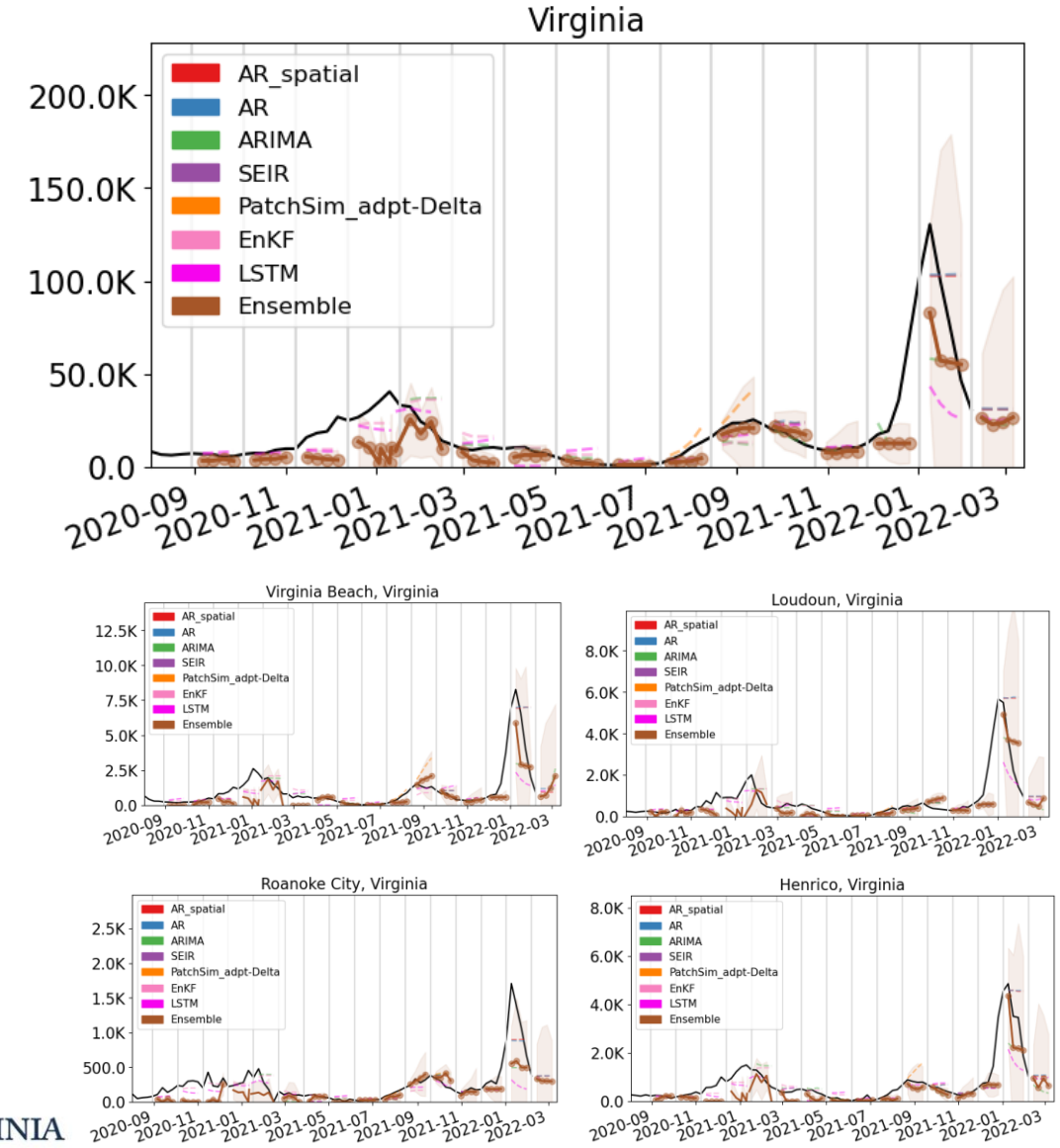
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

<u>Weekly forecasts</u> done at county level.

Models chosen because of their track record in disease forecasting and to increase diversity and robustness.

Ensemble forecast provides additional 'surveillance' for making scenario-based projections.

Also submitted to CDC Forecast Hub.



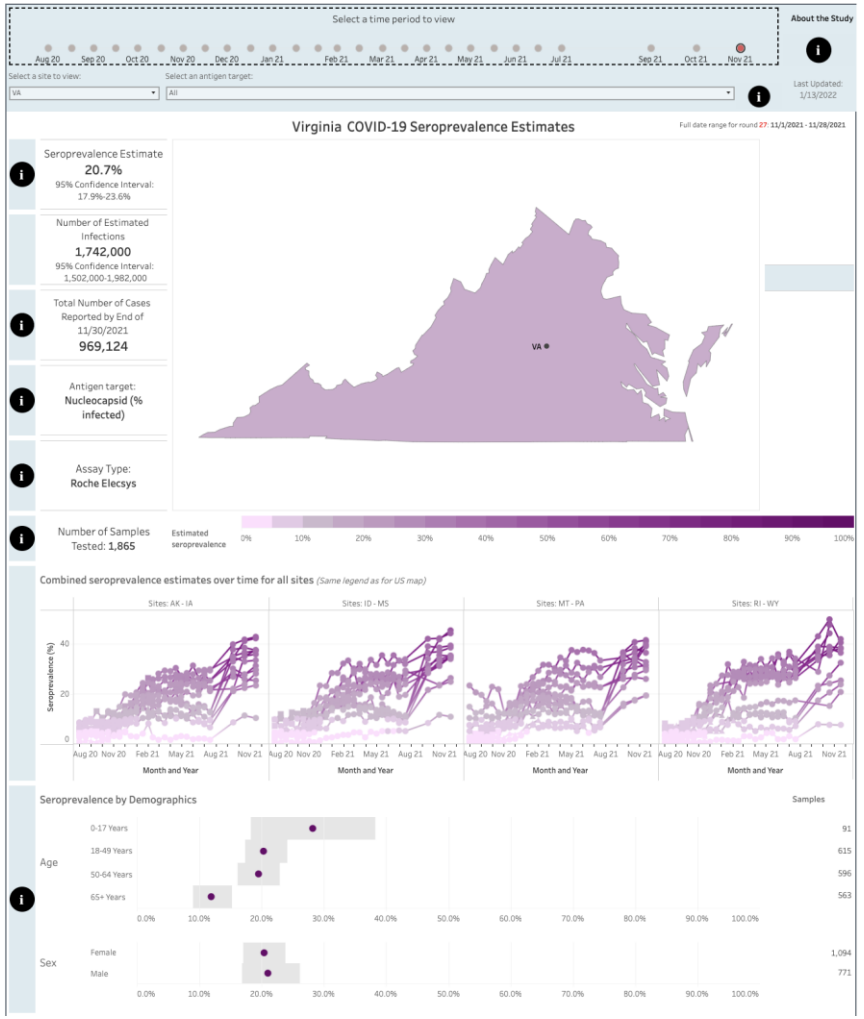
Seroprevalence updates to model design

Several seroprevalence studies provide better picture of how many actual infections have occurred

- CDC Nationwide Commercial Laboratory Seroprevalence Survey

These findings are equivalent to an ascertainment ratio of ~2x in the future, with bounds of (1.3x to 3x)

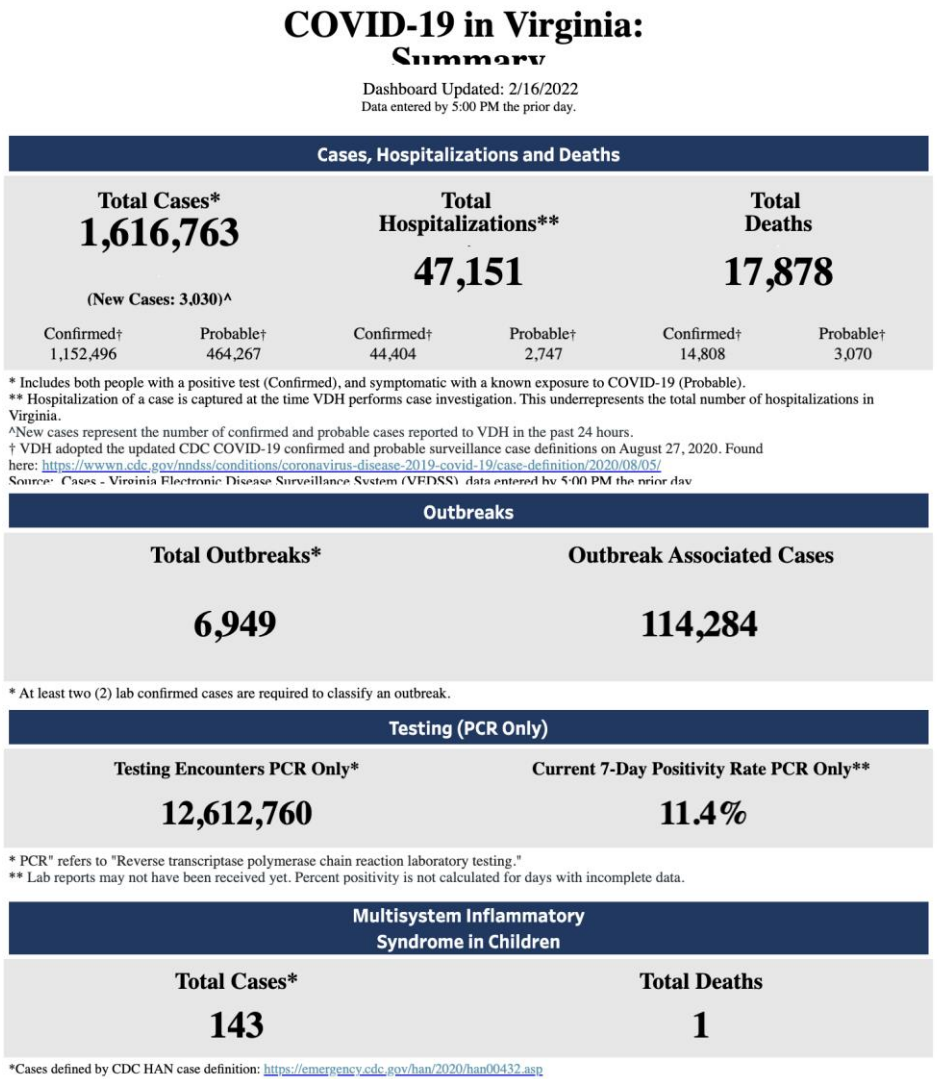
- Thus for 2x there are 2 total infections in the population for every confirmed case recently
- **Case ascertainment is half of that for those with prior immunity**
- Uncertainty design has been shifted to these bounds (previously higher ascertainments as was consistent earlier in the pandemic were being used)



https://covid.cdc.gov/covid-data-tracker/#national-lab

Calibration Approach

- **Data:**
  - County level case counts by date of onset (from VDH)
  - Confirmed cases for model fitting
- **Calibration:** fit model to observed data and ensemble's forecast
  - Tune transmissibility across ranges of:
    - Duration of incubation (5-9 days), infectiousness (3-7 days)
    - Undocumented case rate (1x to 7x) guided by seroprevalence studies
    - Detection delay: exposure to confirmation (4-12 days)
  - Approach captures uncertainty, but allows model to precisely track the full trajectory of the outbreak
- **Project:** future cases and outcomes generated using the collection of fit models run intc the future
  - **Mean trend from last 7 days of observed cases and first week of ensemble's forecast used**
  - Outliers removed based on variances in the previous 3 weeks
  - 2 week interpolation to smooth transitions in rapidly changing trajectories
- **Outcomes**: Data driven by shift and ratio that has least error in last month of observations
  - Hospitalizations: 3 days from confirmation, 6.8% of cases hospitalized
  - Deaths: 11 days from confirmation, 1.45% of cases die



COVID-19 in Virginia: Summary

Dashboard Updated: 2/16/2022
Data entered by 5:00 PM the prior day.

Cases, Hospitalizations and Deaths

Total Cases*	Total Hospitalizations**	Total Deaths
1,616,763	47,151	17,878
(New Cases: 3,030)^		

Confirmed†	Probable†	Confirmed†	Probable†	Confirmed†	Probable†
1,152,496	464,267	44,404	2,747	14,808	3,070

* Includes both people with a positive test (Confirmed), and symptomatic with a known exposure to COVID-19 (Probable).
** Hospitalization of a case is captured at the time VDH performs case investigation. This underrepresents the total number of hospitalizations in Virginia.
^New cases represent the number of confirmed and probable cases reported to VDH in the past 24 hours.
† VDH adopted the updated CDC COVID-19 confirmed and probable surveillance case definitions on August 27, 2020. Found here: https://wwwn.cdc.gov/nndss/conditions/coronavirus-disease-2019-covid-19/case-definition/2020/08/05/
Source: Cases - Virginia Electronic Disease Surveillance System (VEDSS), data entered by 5:00 PM the prior day

Outbreaks

Total Outbreaks*	Outbreak Associated Cases
6,949	114,284

* At least two (2) lab confirmed cases are required to classify an outbreak.

Testing (PCR Only)

Testing Encounters PCR Only*	Current 7-Day Positivity Rate PCR Only**
12,612,760	11.4%

* PCR" refers to "Reverse transcriptase polymerase chain reaction laboratory testing."
** Lab reports may not have been received yet. Percent positivity is not calculated for days with incomplete data.

Multisystem Inflammatory Syndrome in Children

Total Cases*	Total Deaths
143	1

*Cases defined by CDC HAN case definition: https://emergency.cdc.gov/han/2020/han00432.asp

Accessed 10:00am February 16, 2022
https://www.vdh.virginia.gov/coronavirus/

Scenarios – Transmission Conditions

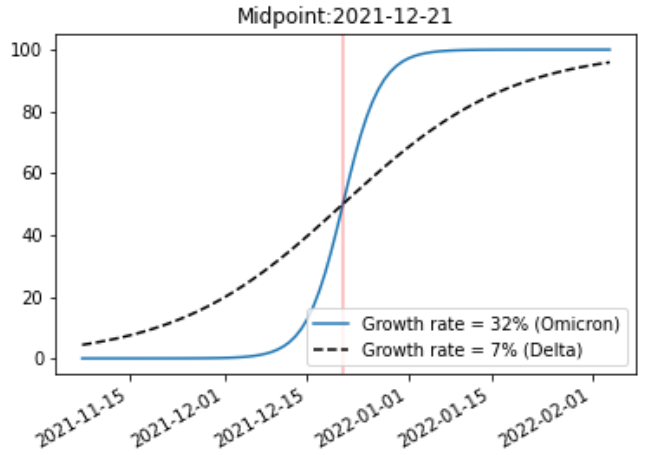
- Variety of factors continue to drive transmission rates
  - Seasonal impact of weather patterns, travel and gatherings, fatigue and premature relaxation of infection control practices
- **Waning Immunity**: Mean of 6 months to a year protection (rate of 0.0027) similar to Pfizer study
- **Projection Scenarios**:
  - **Adaptive:** Control remains as is currently experienced into the future with assumption that Omicron remains as the majority strain, and that infection with Omicron provides protection against Omicron infection in the future
  - **Adaptive-Spring:** Same as Adaptive, except transmission rates are driven down by behaviors and seasonal effects by 60% over the next 2 months (as observed last Fall-Winter wave
  - **Adaptive-DecreasedControl:** Same as Adaptive, except transmission rates are driven up by 60% in the coming 2 weeks
  - **Adaptive-VariantBA2:** Same as Adaptive, but with gradual emergence of BA2 subvariant with a 2x transmission advantage over existing Omicron subvariants

Scenarios – Omicron Description

Omicron shown ability to evade immunity and may be more transmissible

- **Transmissibility**: New evidence suggests that Omicron has **similar transmissibility** to Delta
- **Immune Evasion**: Strong evidence demonstrates that Omicron can cause infection in those with some immunity (natural and vaccine induced). Consensus estimate of **80% immune evasion** allows Omicron to infect 80% of individuals that would have otherwise been protected against Delta. Assume that recovery from Omicron provides protection to infection with Omicron similar pre-Omicron variants
- **Prevalence**: Proportion of cases caused by Omicron variant estimated from growth rates observed in other countries with similar levels of immunity (growth of 32%, doubling in ~3 days)
- **Severity:** Several reports suggest Omicron may not cause as severe disease as Delta, we use a 50% reduction in severity for hospitalizations and deaths
- Studies: South Africa, UK, Canada

Estimated Prevalence curve for US



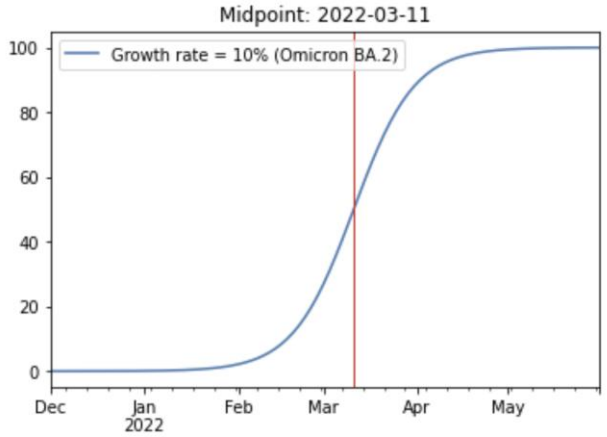
Predominance occurs before Jan 1, 2022

Scenarios – Omicron BA.2 Description

BA.2 shows signs of increased transmissibility

- **Transmissibility**: Analysis of household contacts in Denmark and the UK suggests a 40% to 3x increase in transmission. We assume a 2x boost for this scenario
- **Prevalence**: Detection in US has been widespread but limited, given growth observed elsewhere and US, and current estimated prevalences, this would lead to BA.2 prevalend of 50% in early March
- **Severity:** Assumed to be same as for other Omicron subvariants

Estimated BA2 prevalence projection



This projected prevalence is based on the increase experienced in Denmark the growth rate in VA may be markedly different

Table 3: Relative effect of Omicron VOC BA.2 vs. BA.1

	Susceptibility			Transmissibility		
	Unvaccinated	Fully vaccinated	Booster vaccinated	Unvaccinated	Fully vaccinated	Booster vaccinated
Omicron BA.2 households	2.19 (1.58-3.04)	2.45 (1.77-3.40)	2.99 (2.11-4.24)	2.62 (1.96-3.52)	0.60 (0.42-0.85)	0.62 (0.42-0.91)
Omicron BA.1 households	ref (.)	ref (.)	ref (.)	ref (.)	ref (.)	ref (.)
Number of observations	17,945	17,945	17,945	17,945	17,945	17,945
Number of households	8,541	8,541	8,541	8,541	8,541	8,541

Notes: This table shows odds ratio estimates for the effect of living in a household infected with BA.2 relative to BA.1. Column 1 and 4 shows the relative transmission of BA.2, conditional on being unvac- cinated. Column 2 and 5 shows the relative transmission of BA.2, conditional on being fully vaccinated. Column 3 and 6 shows the relative transmission of BA.2, conditional on being booster vaccinated. Note, all estimates are from the same model, but with a different reference category across column 1-6. The estimates are adjusted for age and sex of the primary case, age and sex of the potential secondary case, size of the household, and primary case sample date. The estimates are furthermore adjusted for vacci- nation status of the potential secondary case and primary case interacted with the household subvariant. 95% confidence intervals are shown in parentheses. Standard errors are clustered on the household level. The odds ratio estimates for the full model are presented in Appendix Table 12, column I

Danish Household Study - MedArxiv

Variant	Household contacts becoming cases / all household contacts	Secondary attack rate amongst household contacts (95% CI)
VUI-22JAN-01 (BA.2)	64 / 476	13.4% (10.7%-16.8%)
Omicron excluding VUI-22JAN-01	10,444 / 101,773	10.3% (10.1%-10.4%)

UK Household Study
PHE Report

Many countries Tracking a 2x Advantage for BA.2 vs. BA.1

Barak Raveh via Twitter

Projection Scenarios – Combined Conditions

Name	Txm Controls	Vax	Description
Adaptive	C	SQ	Likely trajectory based on conditions remaining similar to the current experience, includes immune escape due to Omicron
Adaptive-Spring	Spring	SQ	Assumes rapid decrease observed last Fall-Winter wave plays out till spring, resulting an overall decrease in transmission drivers of 60%
Adaptive-DecreaseControl	Decrease	SQ	Transmission rates in the next couple weeks are increased 60% and remain at that level demonstrate that increases in case rates remain possible despite the historically high rates, remaining vigilant has benefits
Adaptive-VariantBA2	C	SQ	Transmission rates for BA2 infections are doubled. BA2 prevalence rises over the course of next 8 weeks from not detected to ~95%

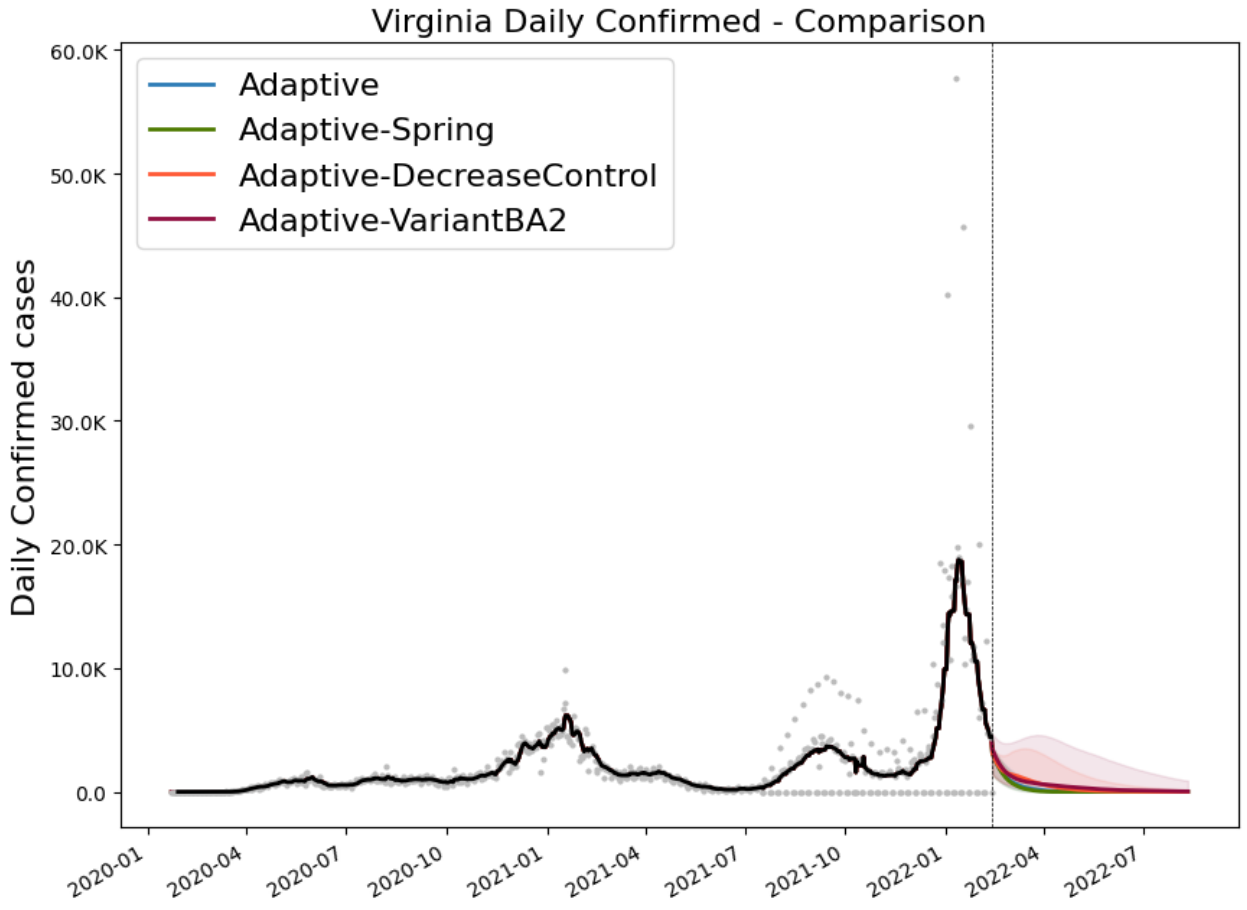
Transmission Controls:
C = Current levels persist into the future
Decrease = Transmission rates are boosted by 60% over next couple weeks and remain at that level
Spring = Transmission rates from mid-Jan 2021 through mid-March 2021 are coarsely replayed, representing a 60% reduction in transmission rate drivers, with Omicron remaining dominant

Vaccinations:
SQ = Status quo acceptance leads to low rates of vaccination through the summer
VO = Vaccination acceptance optimistically expands with increased rates through the summer

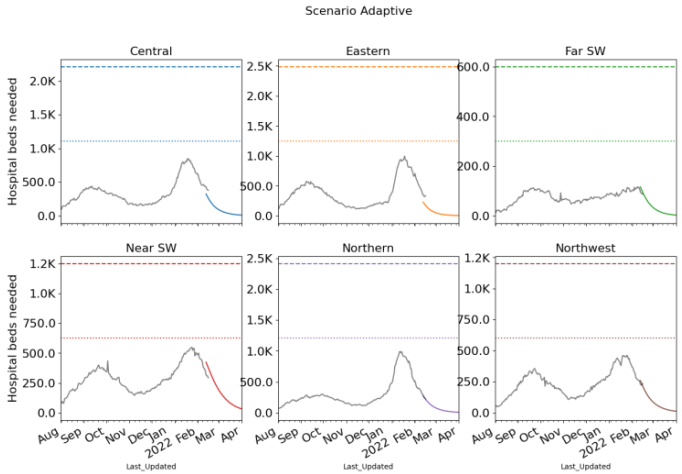
Model Results

Outcome Projections

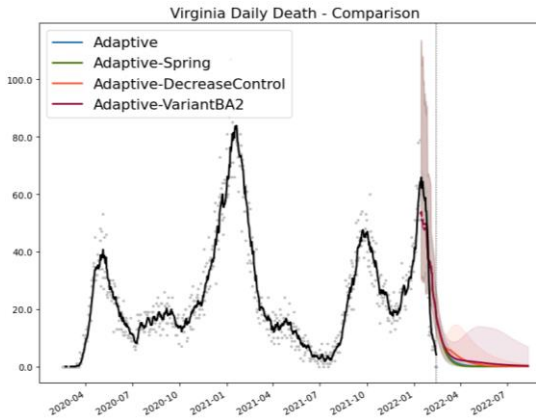
Confirmed cases



Estimated Hospital Occupancy

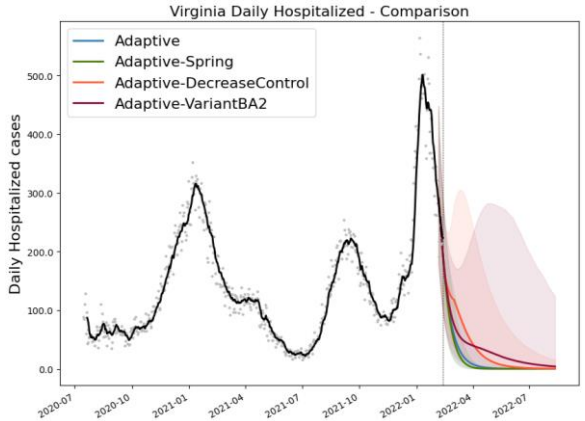


Daily Deaths



Death ground truth from VDH "Event Date" data, most recent dates are not complete

Daily Hospitalized



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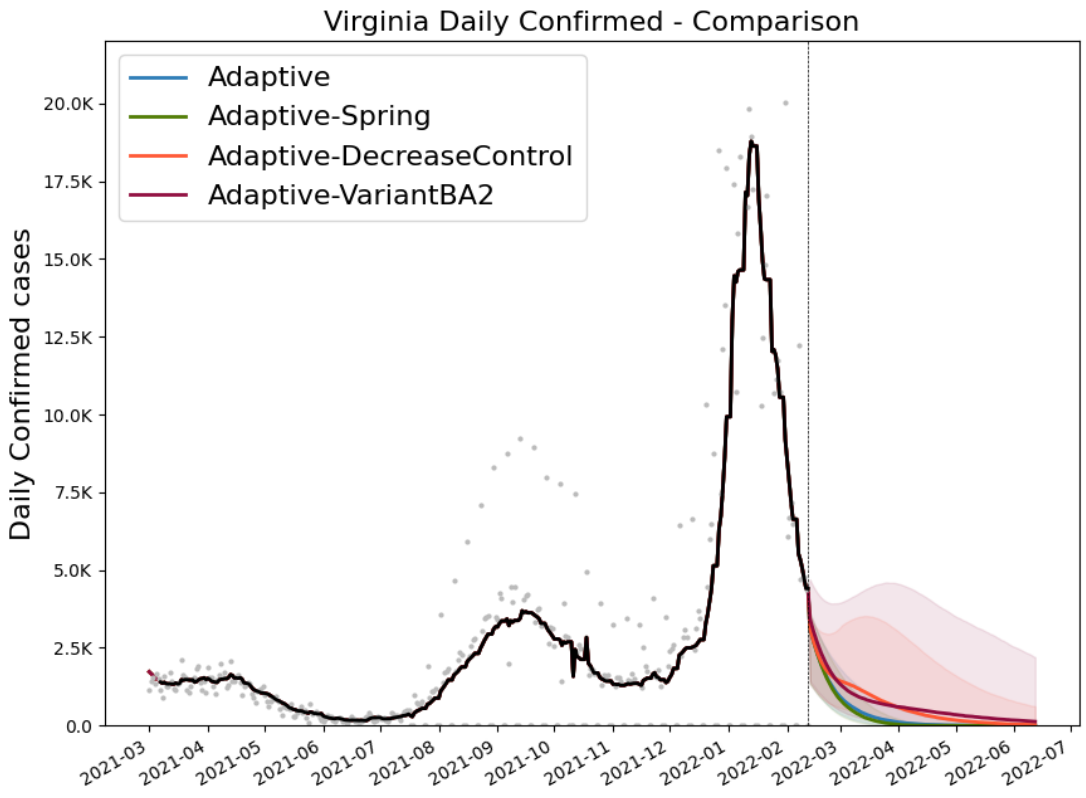
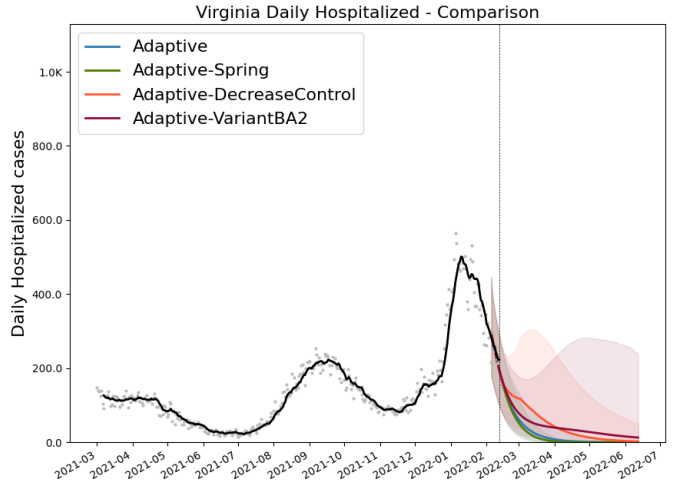
Outcome Projections – Closer Look

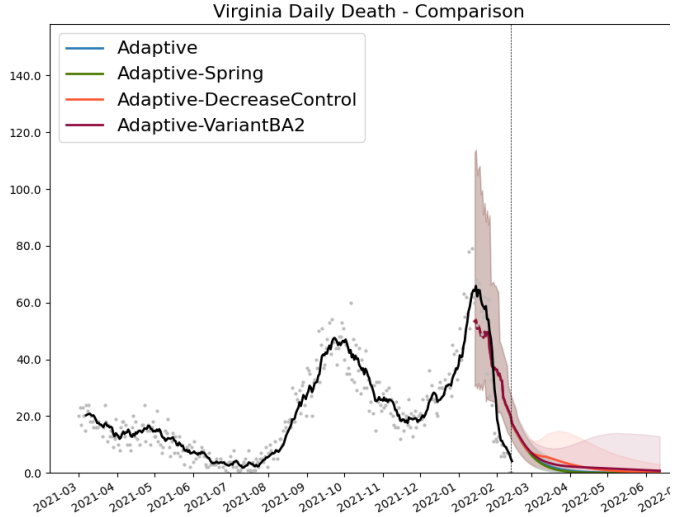
Confirmed cases



Daily Hospitalized



Daily Deaths



Death ground truth from VDH "Event Date" data, most recent dates are not complete

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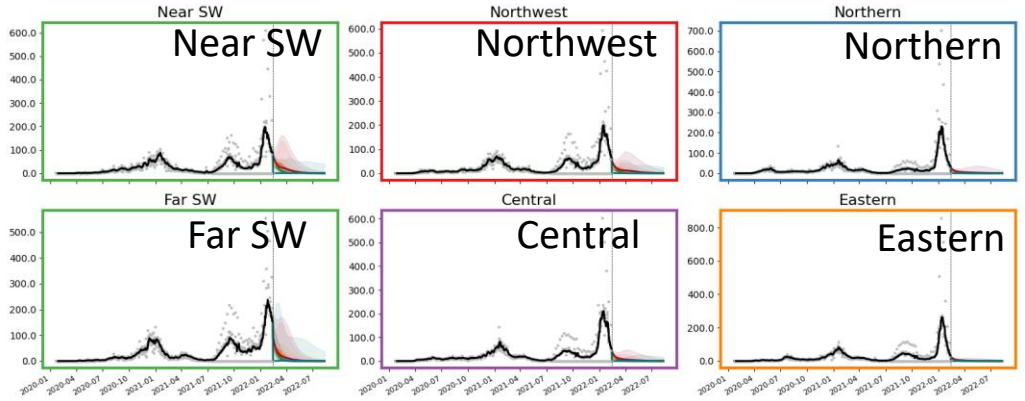
Detailed Projections: All Scenarios

Projections by Region

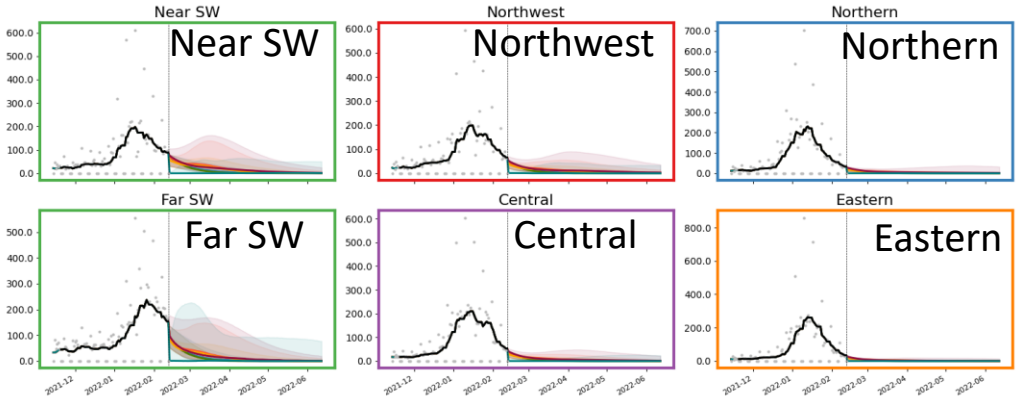


Projections by District

Daily confirmed cases) by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

Detailed Projections: All Scenarios - Closer Look

Projections by Region



Projections by District

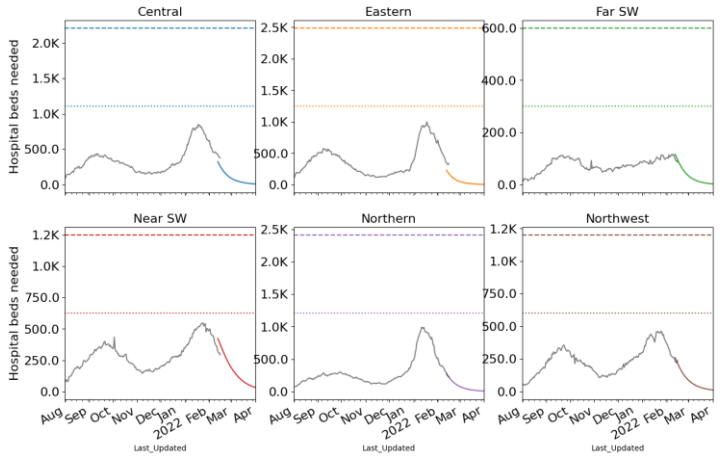
Daily confirmed cases by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

Hospital Demand and Bed Capacity by Region

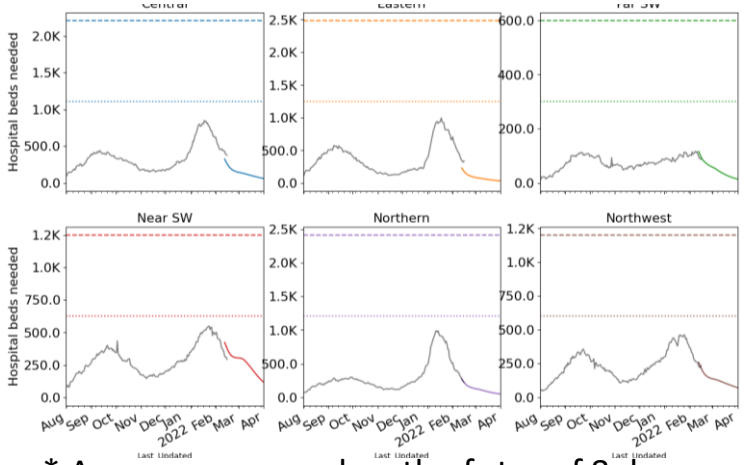
Capacities* by Region

COVID-19 capacity ranges from 80% (dots) to 120% (dash) of total beds

Adaptive



Adaptive – Decrease Control



* Assumes average length of stay of 8 days

Length of Stay more variable with Omicron, occupancy projections may vary as a result, ad-hoc estimation performed per region

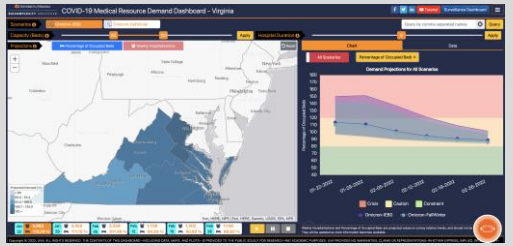
Estimated LOS for Near & Far SW has dropped by 2 days

Projections show continued declines and with expanded capacities, and adjusted length of stay, no capacities exceeded

Length of Stay Estimates

Central	8
Eastern	7
Far SW	4
Near SW	8
Northern	6
Northwestern	8

Interactive Dashboard with regional projections



https://nssac.bii.virginia.edu/covid-19/vmrddash/

Population Immunity

Omicron evades immunity from previous infections and vaccinations, using the model fitted over the course of the pandemic we can track tiers of immunity based on variety of immune events experienced by the population

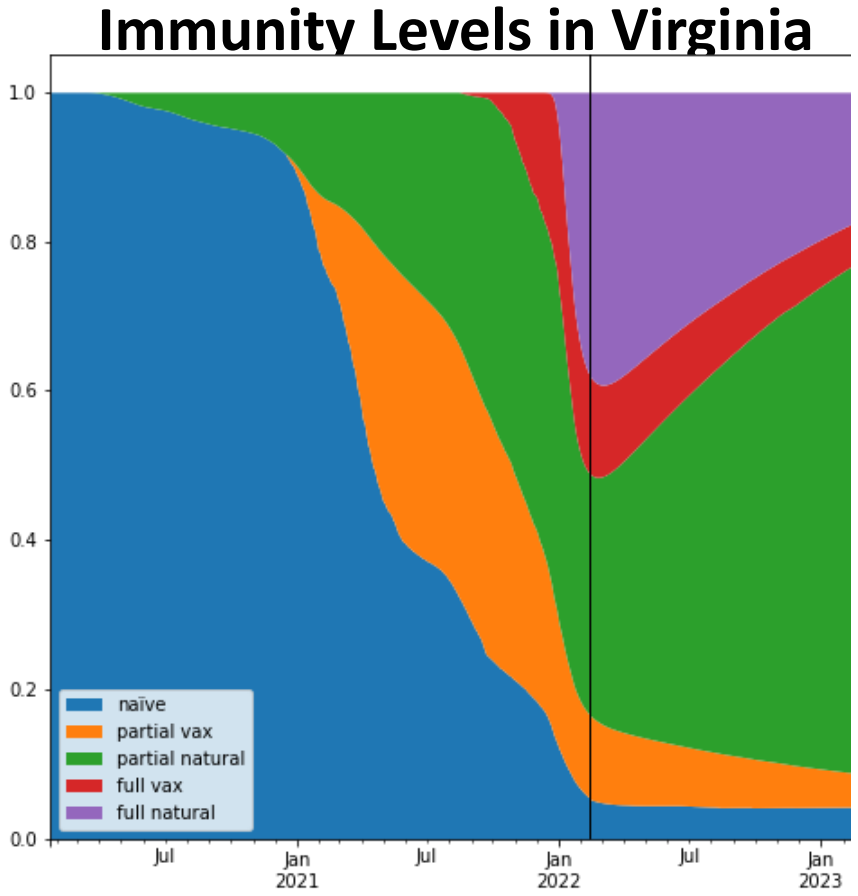
Naïve: No immunity from vaccine or natural infection

Partial from Vax Only: Weakened immunity from waned vaccinations with no natural infection from Omicron

Partial + Natural: Weakened immunity from waned vaccination or natural infection (including Omicron)

Full from Vax Only: Full immunity from vaccination (3 doses) with no natural infection from Omicron

Full + Natural: Full immunity from recent natural immunity from infection with Omicron for all vaccine tiers



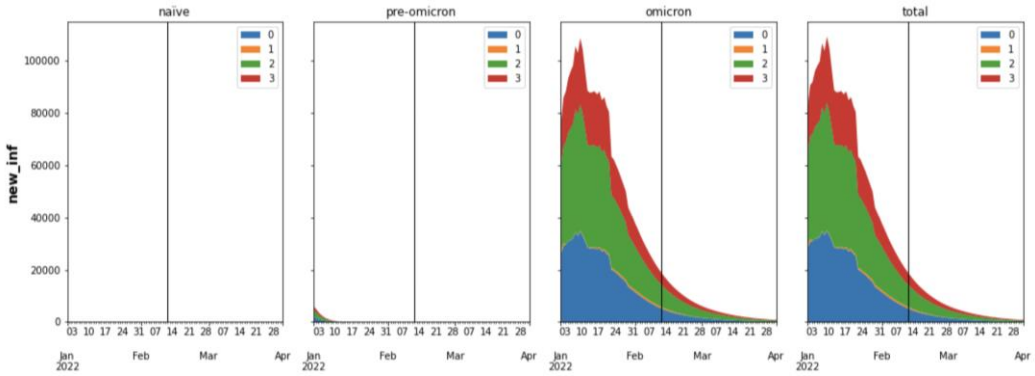
Immunity type	% of pop
Naïve	5.5%
Partial from Vax Only	11.2%
Partial + Natural	32.3%
Full from Vax Only	13.2%
Full + Natural	37.8%

Population Tiers and Strains

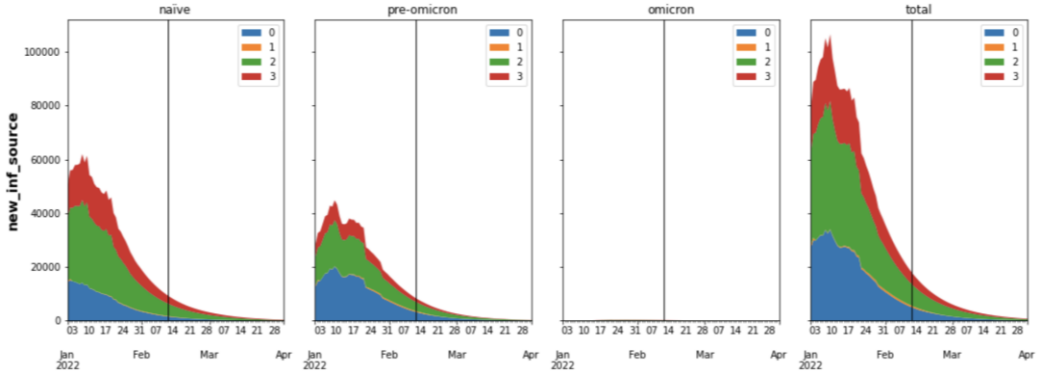
Multi-strain multi-tiered model tracks disease state and immunity of population across variants and 3 levels of vaccination

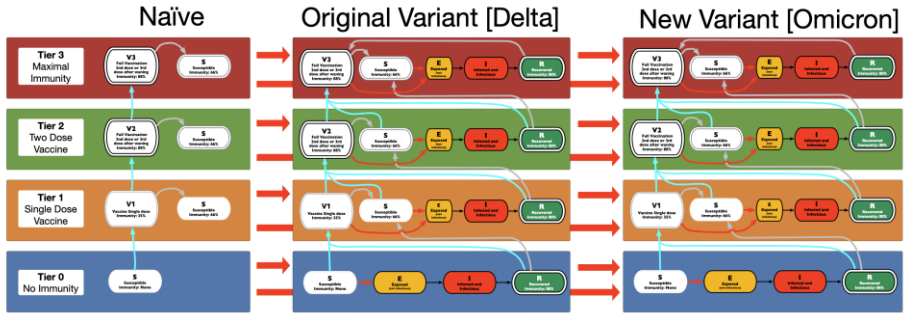
- Detailed look allows view of model's fitted estimate of fractions of the population in any of these immune and infection classes

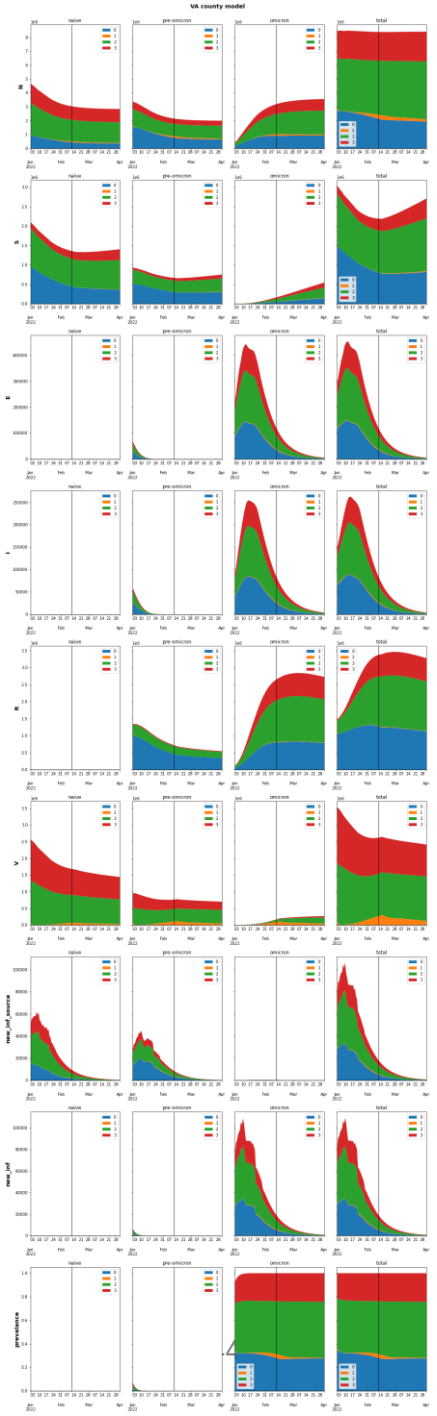
New Infections – Closer Look



Source of Infections – Closer Look







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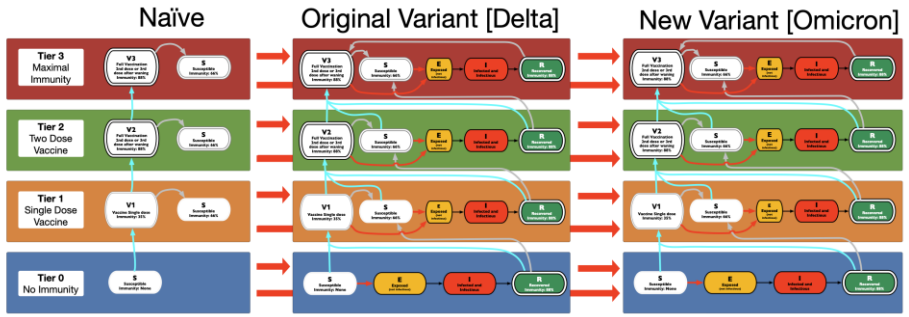
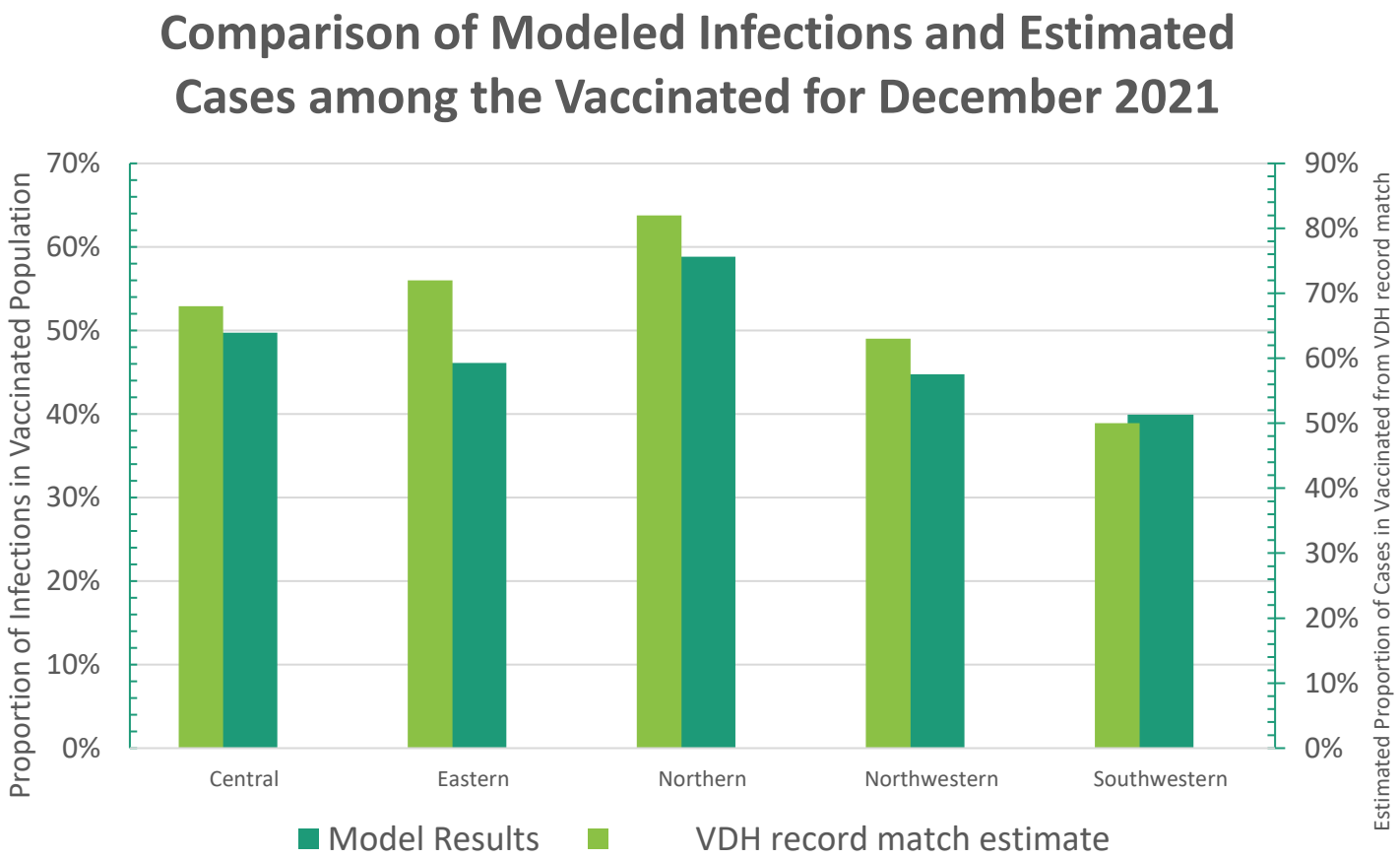
Calibration of Omicron's Immune Evasion

Proportion of recent cases with prior immunity through vaccination reveal the degree of immune evasion of Omicron

- Estimate through unverified matches of VDH vax and case records provide an estimate of recent overall infections among vaccinated
- Model's multi-tiered multi-strain structure provides same measure





Note: Plot uses a 2ndary axis for VDH record match estimate to allow relative comparison between modeled infections and VDH cases, to account for differences in case ascertainment

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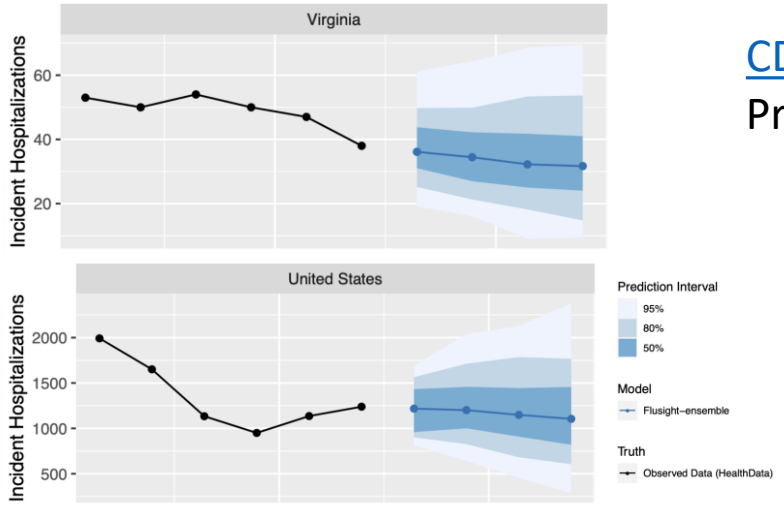
Current Influenza Hospitalization Forecast

Statistical models for submitting to CDC FluSight forecasting challenge

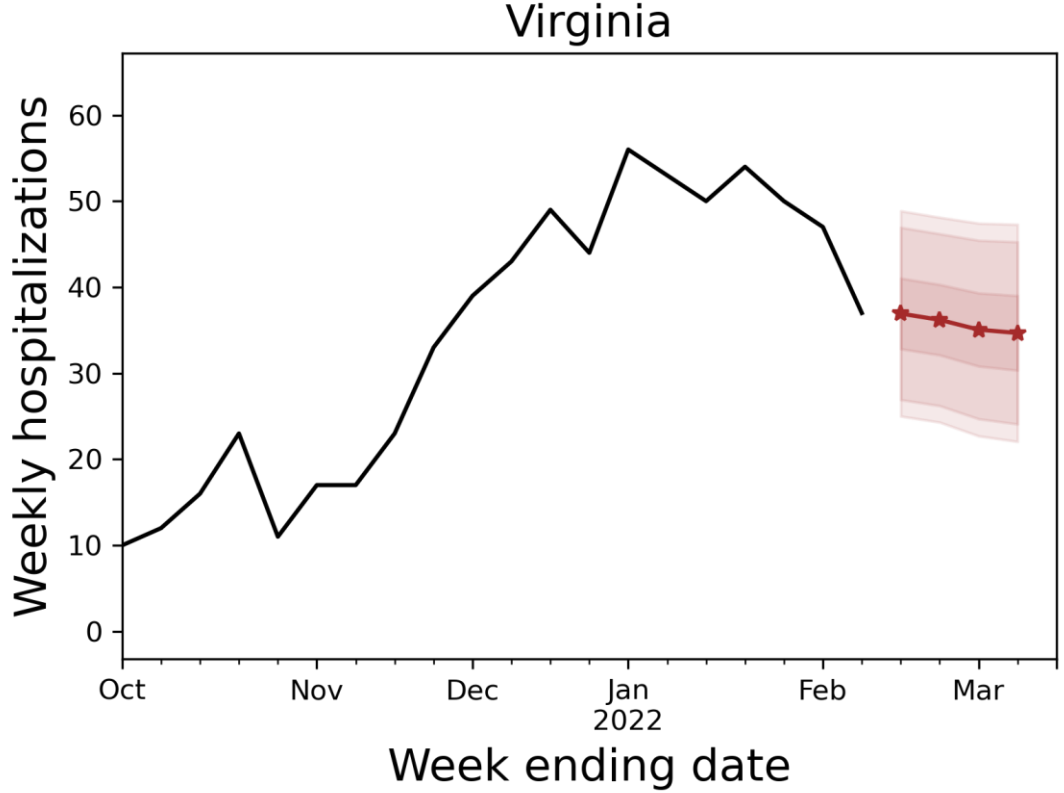
- Similar to COVID-19 case forecasts, uses a variety of statistical and ML approaches to forecast weekly hospital admissions for the next 4 weeks for all states in the US

Influenza A activity dropping in our region
Labs show high levels of H3 this season (Influenza A H3N2 is more severe)



[CDC FluSight](#)
Prelim models

Hospital Admissions for Influenza and Forecast for next 4 weeks (UVA ensemble)



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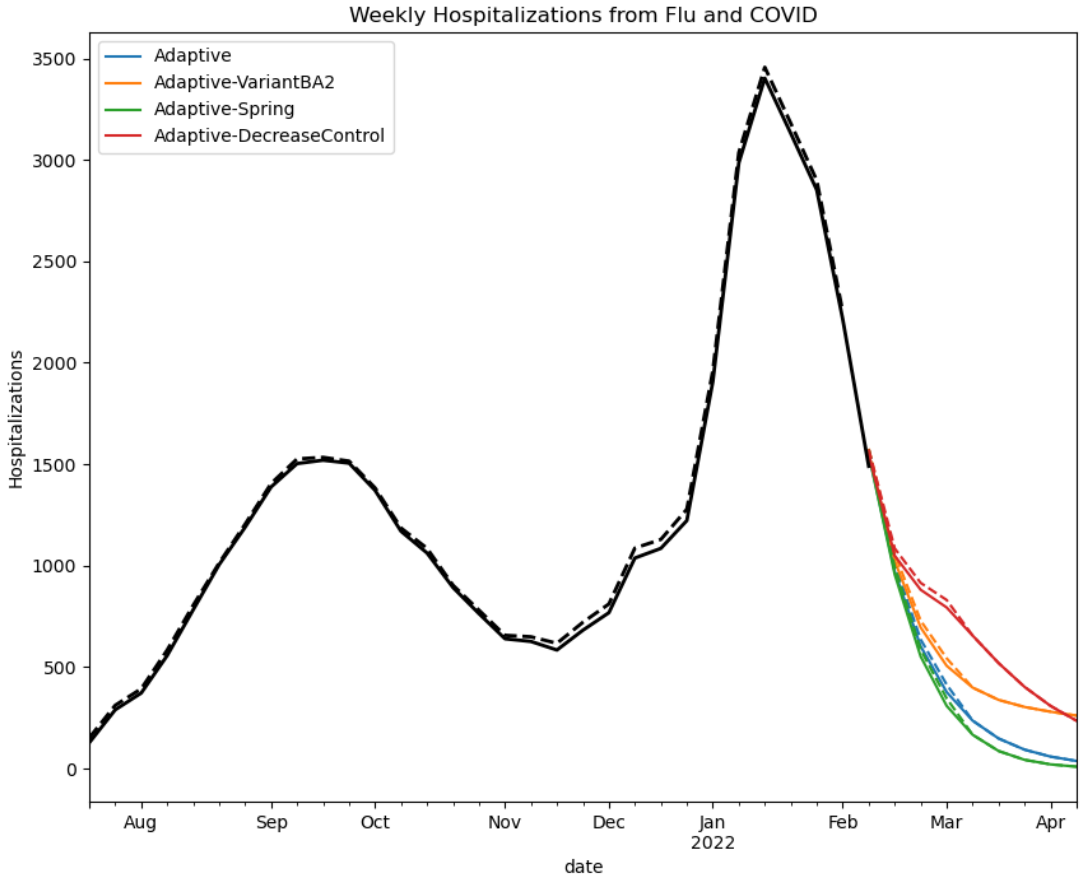
Hospital Admissions from Influenza and COVID-19

Combining Projected COVID-19 admissions with Forecasted Influenza admissions

- Influenza activity is declining as hospital admissions flatten
- COVID-19 hospitalizations are still at very high levels, but declining
- Scale of COVID hospitalizations remains significantly larger than Influenza

COVID Hospitalizations from Adaptive + Flu Hospitalizations from UVA forecast



Key Takeaways

Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

- **Case rates and hospitalizations continue to dramatic decline**
- VA 7-day mean daily case rate is sharply down to 44/100K from 63/100K
  - US is also considerably down to 46/100K (from 72/100K)
- Projections anticipate continued declines:
  - Emerging BA2 subvariant of Omicron could slow and create a broader slow downward in coming weeks
  - Rapidity decline and final level of decline depends on degree of protection to Omicron garnered by previous Omicron infection
- Recent model updates:
  - Further evaluation of dynamics of Omicron immune evasion, roughly align with estimates from VDH
  - Continued refinements to multi-tiered and multi-variant model structure to better capture protections yielded against future infections and other outcomes based on immune histories

The situation continues to change. Models continue to be updated regularly.

Additional Analyses

Weekly Cases and Hospitalizations

Weekly confirmed cases

Week Ending	Adaptive	Adaptive -Spring	Adaptive-Decrease Control	Adaptive-VariantBA2
2/6/22	42645	42645	42645	44794
2/13/22	27620	27622	27620	29642
2/20/22	16314	16248	16608	18713
2/27/22	9481	9078	11533	12184
3/6/22	5710	4991	9728	8615
3/13/22	3541	2722	8440	6678
3/20/22	2188	1397	6894	5556
3/27/22	1359	678	5432	4820
4/3/22	840	278	4212	4273
4/10/22	489	91	3228	3855
4/17/22	282	30	2451	3412
4/24/22	162	5	1850	2996
5/1/22	81	0	1395	2620
5/8/22	46	0	1030	2238

Weekly Hospitalizations

Week Ending	Adaptive	Adaptive-Spring	Adaptive-Decrease Control	Adaptive-VariantBA2
2/6/22	577	577	577	568
2/13/22	1549	1550	1550	1553
2/20/22	971	957	1049	1023
2/27/22	602	552	881	695
3/6/22	377	309	794	506
3/13/22	236	167	655	399
3/20/22	148	86	520	338
3/27/22	93	43	402	303
4/3/22	59	21	309	280
4/10/22	38	9	235	261
4/17/22	24	4	178	243
4/24/22	16	2	134	223
5/1/22	10	1	101	202
5/8/22	7	0	77	181

Overview of relevant on-going studies

Other projects coordinated with CDC and VDH:

- **Scenario Modeling Hub:** Consortium of academic teams coordinated via MIDAS / CDC to that provides regular national projections based on timely scenarios
- **Genomic Surveillance:** Analyses of genomic sequencing data, VA surveillance data, and collaboration with VA DCLS to identify sample sizes needed to detect and track outbreaks driven by introduction of new variants etc.
- **Mobility Data driven Mobile Vaccine Clinic Site Selection:** Collaboration with VDH state and local, Stanford, and SafeGraph to leverage anonymized cell data to help identify

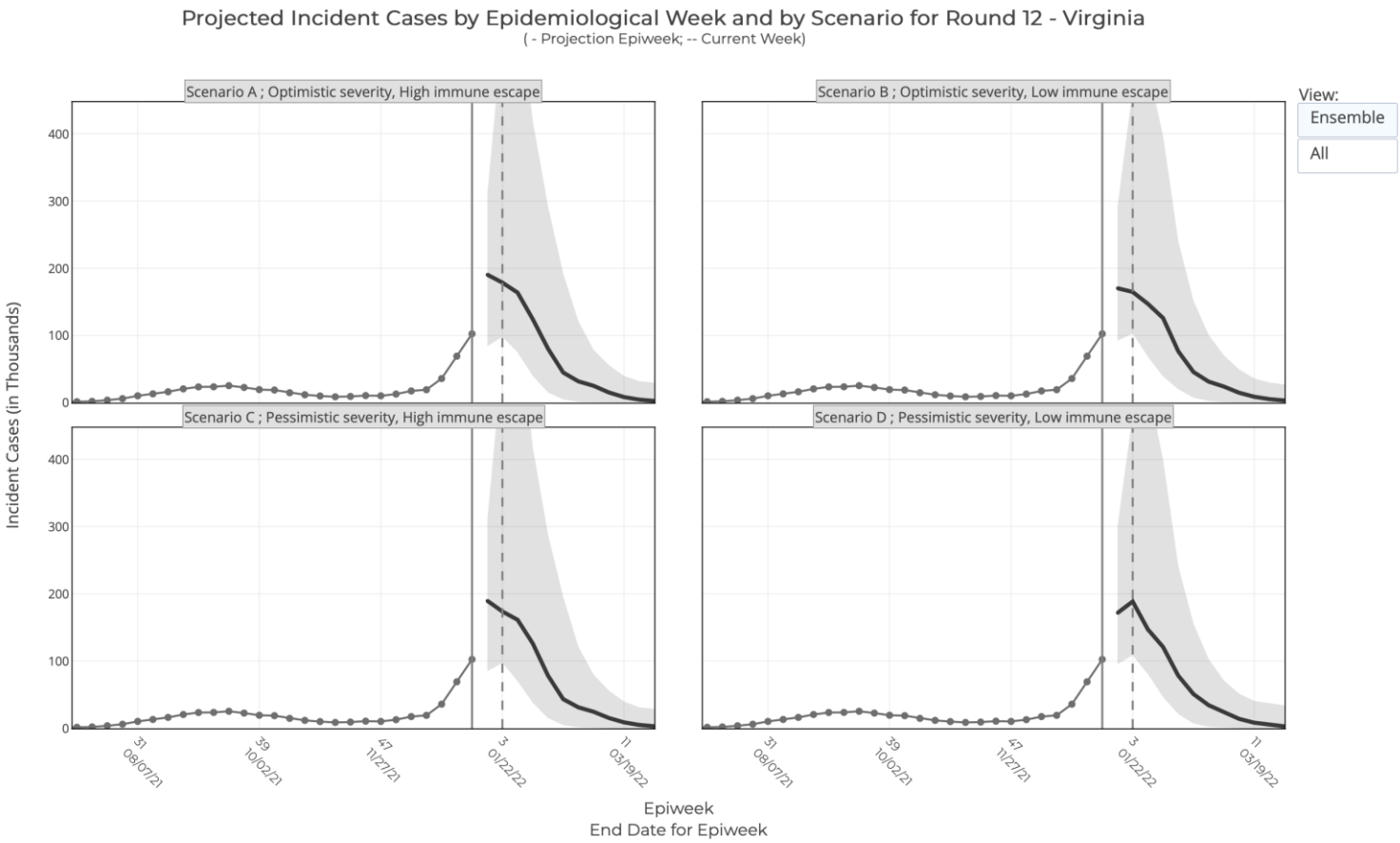
COVID-19 Scenario Modeling Hub

Collaboration of multiple academic teams to provide national and state-by-state level projections for 4 aligned scenarios that vary vaccine rates (high – low) and impact of the Delta variant (high and low)

- Round 12 recently released to assist in federal response to Omicron wave
- Only national consortium tracking Omicron wave well
- Rounds 4-11 now available

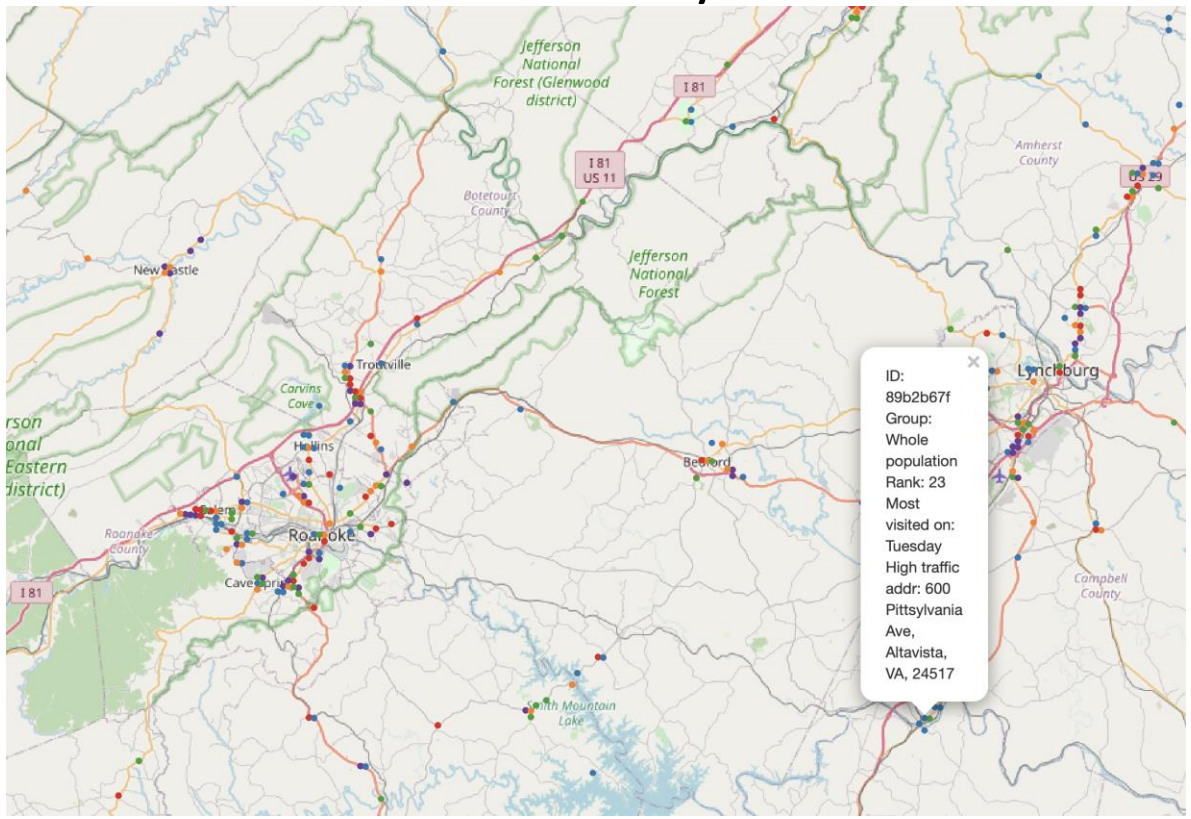
Round 4 Results were published May 5th, 2021 in MMWR

https://covid19scenariomodelinghub.org/viz.html



Data Recommended Mobile Vax Clinic Sites

Detailed and Timely Locations



Data Delivered and Disseminated to Locals

Provides a list of areas most visited by a given demographic group based on SafeGraph mobility data that links visits to specific sites and the home Census Block Group of the anonymized visitors

Demographic Groups: Black, Lantinx, Young Adults (20-40), Unvaccinated, and Whole Population

Data Included: Rank, Weight, most visited Day of Week, Highly Visited Address, and Lat-Long of area

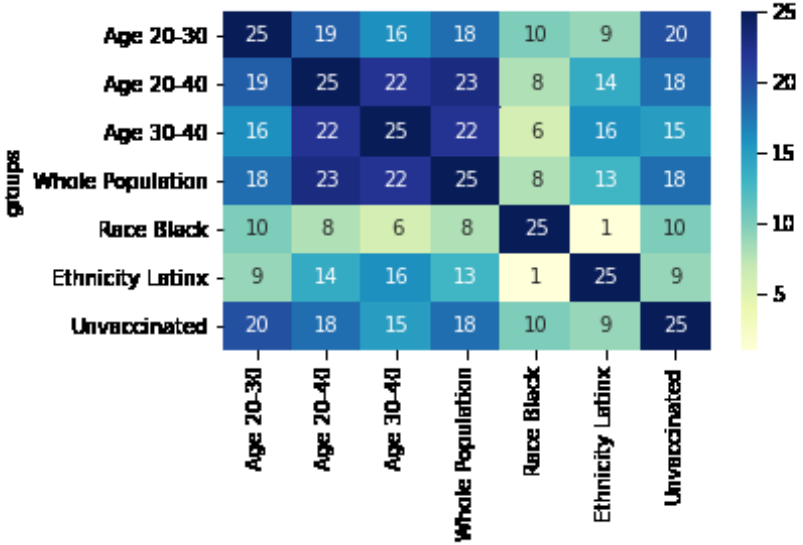
Goal: Provide frequently visited locations based on populations and vaccination levels one desires to reach

Example: List of location in the Southside frequented by 20-40 year olds

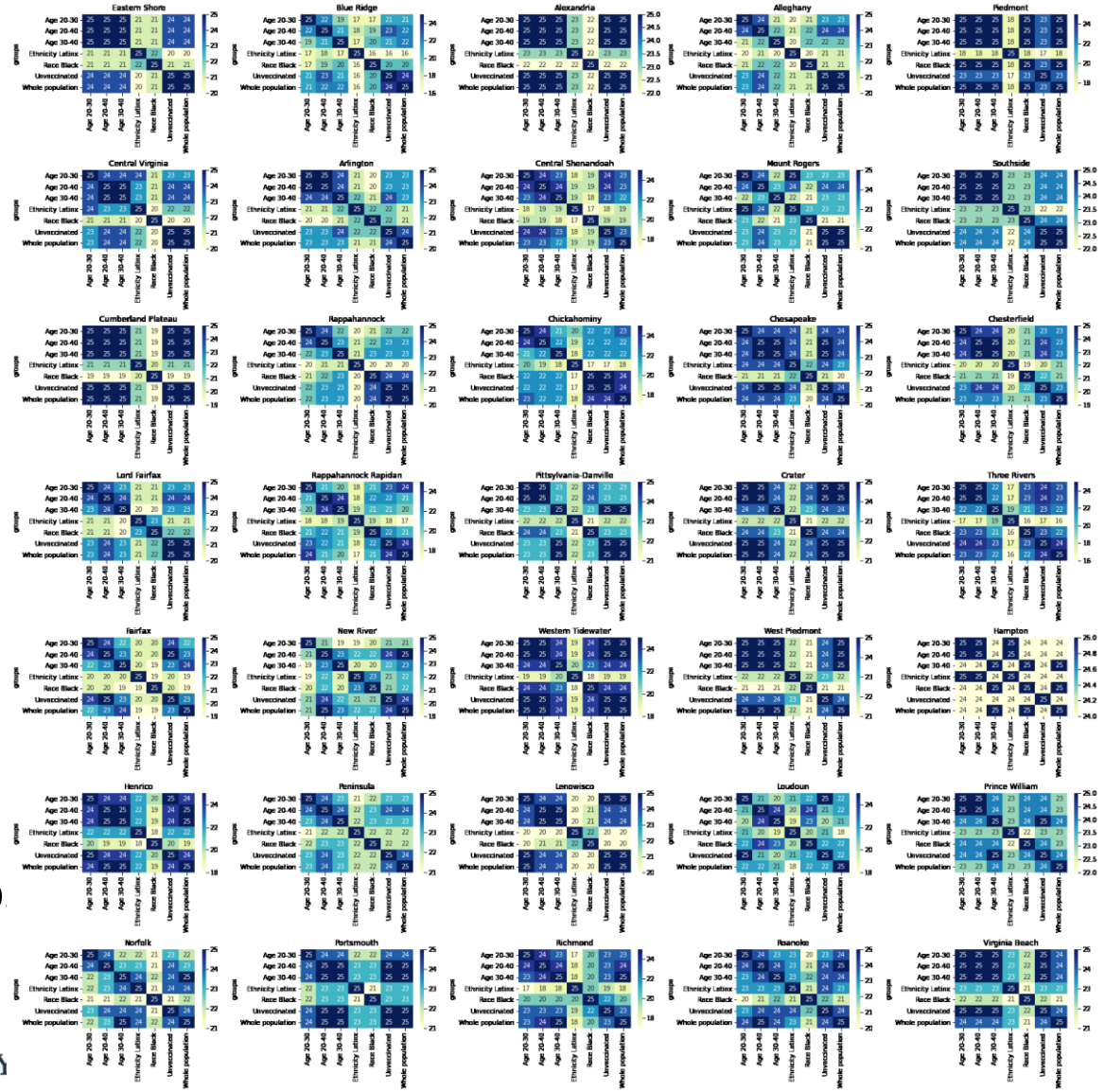
Data Recommended Mobile Vax Clinic Sites

Overlap of locations between groups

State Level



Within VDH Health Districts



Different groups visit different areas

- Least overlap between Black and Latinx
- Overlap in ages highest, but drops with large gap
- Districts have different overlap patterns

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Biocomplexity page for data and other resources related to COVID-19: https://covid19.biocomplexity.virginia.edu/

Questions?

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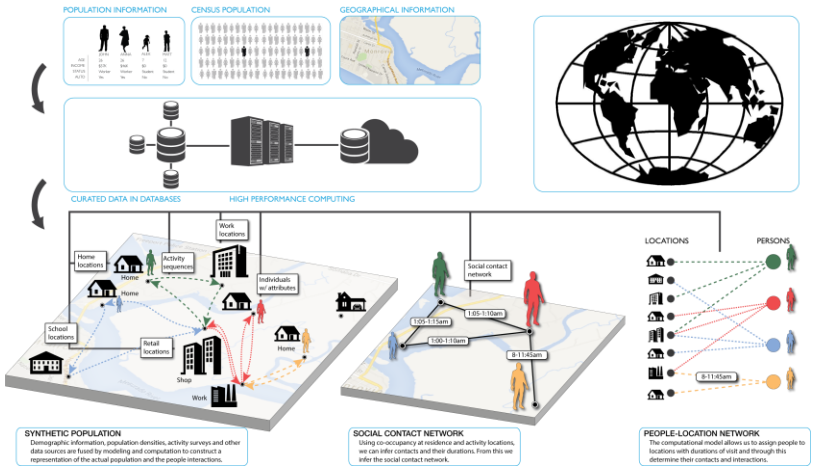
Supplemental Slides

Agent-based Model (ABM)

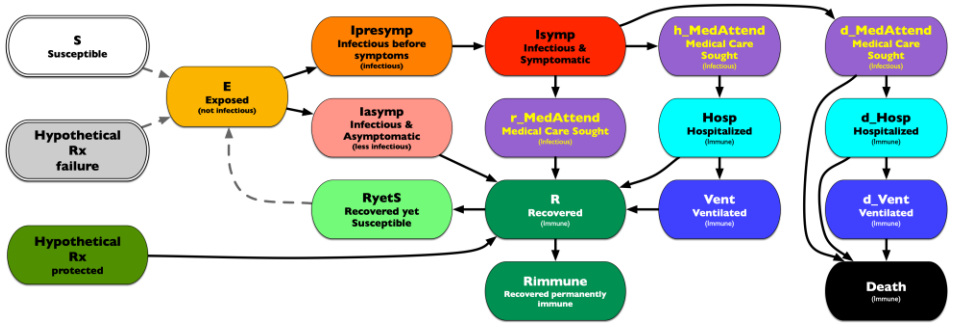
EpiHiper: Distributed network-based stochastic disease transmission simulations

- Assess the impact on transmission under different conditions
- Assess the impacts of contact tracing



Synthetic Population

- Census derived age and household structure
- Time-Use survey driven activities at appropriate locations



Detailed Disease Course of COVID-19

- Literature based probabilities of outcomes with appropriate delays
- Varying levels of infectiousness
- Hypothetical treatments for future developments